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Southern Illinois Univ. at Carbondale

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COAL MINE RELATED STREAM SEDIMENT GEOCHEMISTRY IN SOUTHERN ILLINOIS

by

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When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

A regional survey in stream sediment geochemistry indicates that downstream areas from coal mines or coal related land uses can contain four times the median value of several elements, specifically cadmium cobalt, copper, iron, manganese, nickel and zinc. In those parts of a mine-impacted stream where low pH is maintained, metals can be leached from the stream sediment to further increase the concentrations in water. This phenomenon is significant to watershed managers and potential downstream water users in that they can begin to analyze their water quality problems. Further information on stream sediment geochemistry can be obtained from the Industrial Pollution Control Division of the IERL-Ci.

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ABSTRACT

The stream sediment geochemistry of several elements, specifically cadmium, cobalt, copper, iron, manganese, nickel and zinc, has been examined in a six county area of Southern Illinois that has been greatly impacted by coal-mining activities. Arsenic and chromium were also investigated, but only in isolated areas.

A regional survey of these elements in stream sediments indicates that most areas of anomalously high concentrations (four times the median value) of cadmium, cobalt, iron, nickel and zinc generally occur downstream from coal mines or other areas of coal-related land uses. Most such anomalously high stream sediments are within eight kilometers of the coal-related area. Only manganese, and to a lesser extent copper, show distribution patterns unrelated to mining.

In three streams singled out for more detailed study, there are marked relationships among the pH of mine drainage water, the concentrations of metals in the water, and the concentrations of metals in corresponding stream sediment. Water with low pH shows seasonal summer highs in metal content and can enter streams already carrying large concentrations of metals that have either been released during the oxidation of pyrite or leached from the rocks with which the acid drainage has come into contact. In those parts of a mine-impacted stream where low pH is maintained, metals can be leached from the stream sediment to further increase the concentrations in water. On the other hand, if the pH of a stream is increased, metals will tend to precipitate out of the water and become part of the stream sediment. The precipitation reactions can occur at considerable distances downstream from the source of pollution, and account for the observed regional distribution of anomalously high concentrations of metals in sediment.

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SECTION 1

INTRODUCTION

Southern Illinois is an area that has been extensively mined for coal for many years. Coal-bearing Pennsylvanian-aged rocks crop out in a broad band that curves gradually across the southern part of the state. Where the coal beds in these rocks are shallow, surface mining has been widespread. North of the shallow outcrop area, where the coal beds are deeper, underground mines are abundant. As of mid-1971, 21,987 hectares of the six county area of this study had been affected by surface mining activities and surface disturbances related to underground mining. This amounts to three percent of the land area in these counties (Haynes and Klimstra, 1975).

Prior to passage of various State and Federal reclamation laws, some of the mining practices used in Illinois resulted in the creation of problem sites which have generated large amounts of acid mine drainage. In the southern Illinois area, acid mine drainage typically arises in one of two general settings. First, old, coarse refuse (gob) piles and fine refuse (slurry) impoundments which have been exposed to the weathering processes have created areas of intense production of acid drainage and related pollutants. Second, there are some areas in which the overburden has a high potential for the production of acid drainage and little potential to neutralize it. Strip mines exposing such material to air and water can create large non-point source areas of acid mine drainage.

The polluted waters generated from these sources are known to carry appreciable concentrations of several potentially toxic trace elements. Monitoring programs by the Illinois Environmental Protection Agency, the Greater Egypt Regional Planning and Development Commission and numerous studies of individual sites have shown appreciable quantities of zinc, cadmium, nickel, cobalt, iron, manganese and minor amounts of copper in the streams draining such areas. However, not all of the contaminants moved by a stream are dissolved in the water. Many are carried as part of the particulate suspended and bed load of a stream, to be picked up, dropped, or rolled along as circumstances dictate. The literature suggests that such elements may be either removed from solution to become part of the particulate load or may be dissolved from solids and reintroduced into the water, depending upon the chemical environment. Indeed, some studies suggest that much of the trace element load of a stream is carried in such a non-dissolved state. Thus, a monitoring program that examines only the dissolved portions of a polluted stream may miss large quantities of metals that are being transported in another manner. This study is an attempt to ascertain the extent of distribution of metals in the stream sediment of the mine-impacted portion of southern Illinois and to determine the conditions under which metals move from the water to become a part of the sediment and vice versa.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Based on the data obtained in this study, the following conclusions can be made:

Various metals such as arsenic, cadmium, cobalt, copper, iron, manganese, nickel, and zinc are present in the rocks of the coal mining region of southern Illinois in amounts generally equal to or slightly greater than the content in similar rocks around the world.

Sulfuric acid created by the oxidation of pyrite can mobilize these elements, allowing them to move into nearby surface drainages.

Once in the stream, the fate of a particular metal depends on geochemical factors, such as pH, which determine whether it will stay in solution or become a part of the stream sediment.

Those parts of streams less than 8 kilometers downstream from coal mining activities frequently have trace element contents in bottom sediment significantly higher than those not influenced by coal-related activities.

Parts of streams having low pH values consistently have higher concentrations of the trace elements in water than in areas with high pH values.

Sampling sites with low pH values commonly show a strong seasonal variation of concentration of elements in water, which is marked by a increase in concentration of all trace elements in the summer and fall months. Sites with high pH values do not develop a seasonal trend but instead have various peaks and lows in concentration occurring throughout the year.

Sites with low pH and a seasonal trend in water quality show strong interelemental behavioral similarity. Conversely, sites with high pH values that lack the seasonal trend do not have strong interelemental behavioral similarity.

Concentrations of all trace elements in water decrease with greater distance from the source, due to dilution from additional surface water or groundwater and/or to the precipitation of elements out of solution.

Rainfall may dilute the concentrations of the trace elements in water. The influence of this factor increases in streams of greater drainage area.

Sampling sites with low pH values consistently have lower concentrations of the trace elements in stream sediment than sites with high pH values.

None of the streams studied showed significant seasonal variation for trace elements in sediments. Most values fluctuate throughout the year, with erratic peaks and lows. However, high or peak values more often occur in summer months.

Concentrations of most of the trace elements in sediment decrease with increasing distance downstream from a polluting source. When high pH-high sediment concentration streams mix with low pH-low sediment concentration streams, the resulting values for metals in sediment are not necessarily intermediate. Some elements are of lower values than either contributing stream, suggesting a dissolution of these elements from the sediment. Iron and chromium are frequently in higher concentration in the sediment below the confluence than in either contributing stream, indicating precipitation of these elements. The specific behavior of the metals mainly depends on the pH of the water below the mixing zones.

The higher trace element content of stream sediment below coal mines is a result of leaching of the elements in or near the mines by acidic water coupled with reprecipitation when the acidic water is neutralized. Consequently it is recommended that monitoring stream sediment for trace element pollutants not be required, because pH and trace element content in the mine effluent will control mine-related downstream changes in trace element content of the sediments.

SECTION 3

REGIONAL SETTING

LOCATION

This investigation of the geochemistry of cadmium and other metals related to coal mining is restricted to a six county area of southern Illinois. The counties involved are Gallatin, Jackson, Perry, Randolph, Saline, and Williamson (Figure 1). The amount of land that has been disturbed by surface mining and the surface effects of underground mining of coal in these counties ranges from over seven percent of Perry County to less than one percent of Gallatin County (Haynes and Klimstra, 1975). Table 1 indicates the amount of surface disturbance related to coal-mining activities.

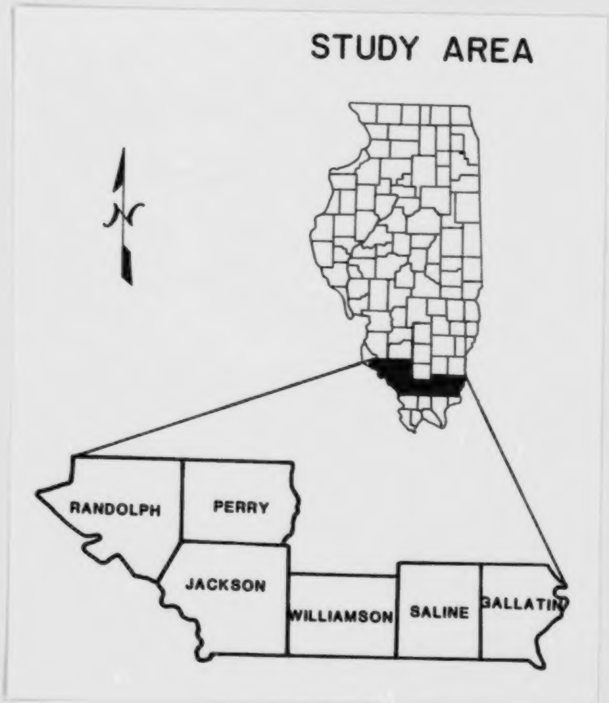


Figure 1. Location of study area.

TABLE 1. AREAS DISTURBED BY COAL MINING ACTIVITIES*

County	Hectares in county	Area disturbed	Percent
Gallatin	84,955	600	0.71
Jackson	156,181	1,983	1.27
Perry	114,740	8,222	7.17
Randolph	153,851	2,195	1.43
Saline	99,459	3,846	3.87
Williamson	110,596	5,140	4.65

*Source: Haynes and Klimstra, 1975.

GENERAL GEOLOGY

Coal-bearing formations of Pennsylvanian age crop out across southern Illinois in a west to northwest trending arc (Figure 2). Their dip is toward the north and northeast, resulting in an older to younger progression of formations from south to north. This simple pattern is complicated somewhat by several structural features, including several fault systems and two major folds. Of the fault systems within the study area, the Cottage Grove Fault System, the Wabash Valley Fault System and the Fluorspar Area Fault System displace the coal beds on the order of a few meters to a few tens of meters. The Shawneetown Fault, on the other hand, has displacements estimated to be on the order of hundreds to thousands of meters. South of the Shawneetown Fault, the coal-bearing rocks are folded into a U-shaped outcrop pattern which has brought several of the coals to the surface in a relatively small area. When encountered, all of these features affect the mining of the coals to some extent and at times establish the physical limits of a mining operation.

Another structural feature of major importance is the DuQuoin Monocline. Unlike the previously mentioned features, this structure was active during the time of deposition of the Pennsylvanian rocks and separated a relatively stable area which was dominated by shallow marine influences on the west (western shelf area) from one on the east which was gradually subsiding. The subsiding eastern area was the site of active delta building during the time of coal deposition. The different types of environments resulted in somewhat different overburden rocks associated with the coal beds, and this in turn has influenced the water quality in the different parts of the area. West of the monocline, there are numerous limestone beds; east of the structure limestones are sparse.

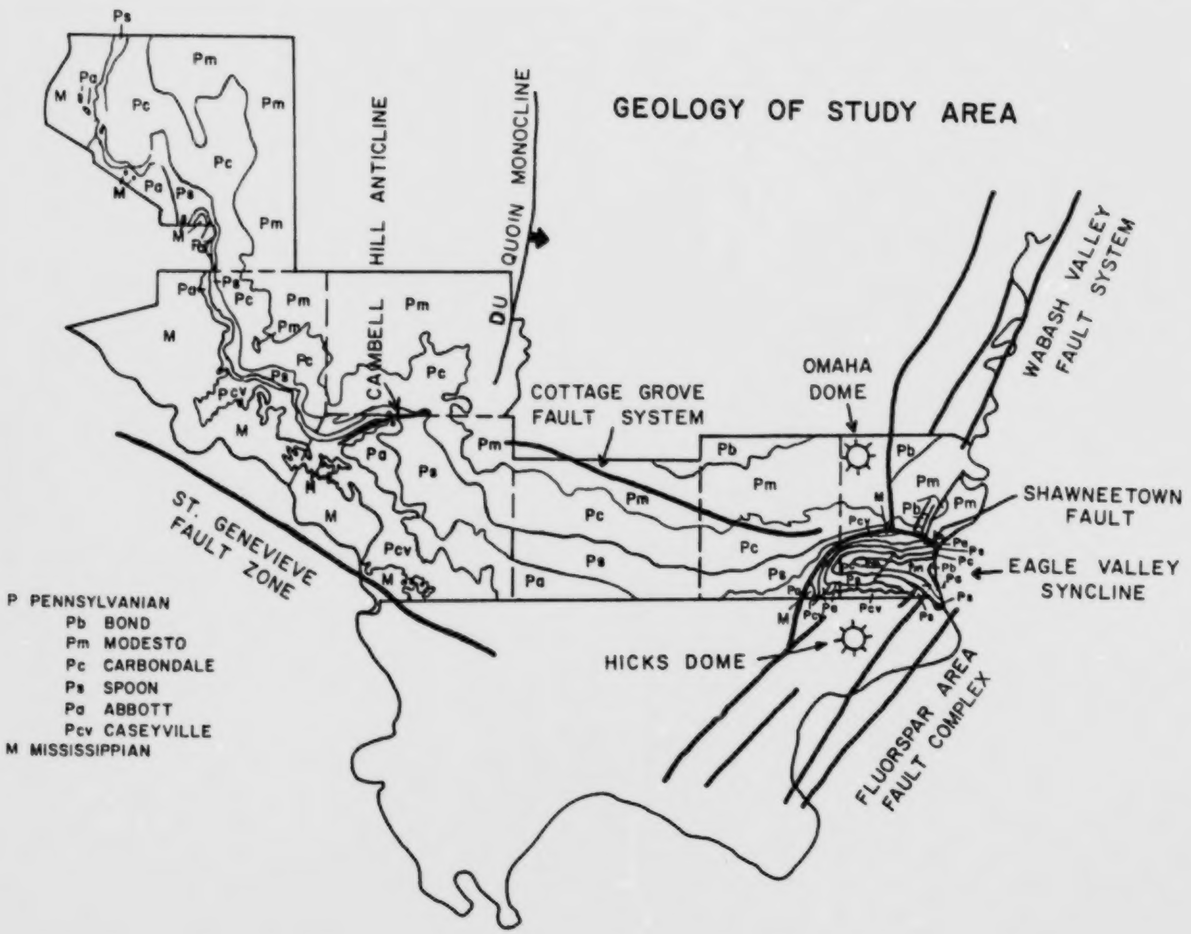

GEOLOGY OF STUDY AREA
HILL ANTICLINE
CAMBELL
DU QUOIN MONOCLINE
COTTAGE GROVE FAULT SYSTEM
OMAHA DOME
WABASH VALLEY FAULT SYSTEM
SHAWNEETOWN FAULT
EAGLE VALLEY SYNCLINE
HICKS DOME
FLUORSPAR AREA FAULT COMPLEX
ST. GENEVIEVE FAULT ZONE
P PENNSYLVANIAN
Pb BOND
Pm MODESTO
Pc CARBONDALE
Ps SPOON
Pa ABBOTT
Pcv CASEYVILLE
M MISSISSIPPIAN

Figure 2. Geology of study area.

The important coal-bearing formations are the Spoon and the Carbondale Formations. The Spoon Formation consists largely of sandstone, siltstone and gray shale, with very little limestone. Two important coal beds, the Davis and DeKoven coals, are commercially important in the southern parts of Williamson and Saline Counties. The fact that there is only about six meters of material between these two coals allows them to be mined simultaneously. At some locations, the stratigraphic sequence between the coals is partially made up of a pyrite-rich black shale that contains up to twelve percent sulfur. When exposed at the surface, this pyritic shale can produce considerable amounts of acid. Extensive mining of the Davis and DeKoven coals has produced areas of intense pollution because of this unfortunate stratigraphy.

The Carbondale Formation overlies the Spoon Formation and differs from it by having larger proportions of limestone and shale. The limestones tend to become more abundant higher in the stratigraphic section and west of the DuQuoin Monocline. Two important coals are also present in this formation. These are the Harrisburg (Number 5) and the Herrin (Number 6) coals. The Number 6 coal is stratigraphically above the Number 5. East of the DuQuoin Monocline, in the area of Williamson and Saline counties, the stratigraphic interval between the two coal beds is on the order of 43 meters and the two coals are mined separately. The generally low dip of the strata in this area results in the outcrop lines of the two coals being separated by as much as 1.5 kilometers, giving rise to two series of parallel strip mines. Further to the west, particularly in the vicinity of the DuQuoin Monocline, the stratigraphic interval between these coals becomes much thinner. In Perry and Randolph counties, only about 10 meters of rock separate the beds and the two coals are commonly removed in a single mining operation.

SECTION 4

BACKGROUND GEOCHEMISTRY

Many of the rocks in southern Illinois contain the mineral pyrite (FeS_2). When this mineral is exposed to the atmosphere, it reacts with oxygen and water to form sulfuric acid according to a series of reactions:

$$FeS_2 + 7/2\ O_2 + H_2O = Fe^{+2} + 2SO_4^{-2} + 2H^+ \qquad (1)$$

$$Fe^{+2} + 1/4\ O_2 + H^+ = Fe^{+3} + 1/2\ H_2O \qquad (2)$$

$$Fe^{+3} + 3H_2O = Fe(OH)_3 + 3H^+ \qquad (3)$$

$$FeS_2 + 14Fe^{+3} + 8H_2O = 15Fe^{+2} + 2SO_4^{-2} + 16H^+ \qquad (4)$$

Equation 1 shows pyrite combining with oxygen and water to generate ferrous sulfate and sulfuric acid. Equations 2 and 3 show the oxidation and subsequent precipitation of the iron, with the net liberation of two additional hydrogen ions. These three equations show that the complete oxidation of pyrite and subsequent precipitation of the iron will result in the generation of two moles of sulfuric acid for each mole of pyrite consumed. Equation 4 shows an alternate, anerobic method for the oxidation of pyrite, with the same overall results as in equation 1. (Note that to generate 14 ferric ions, 14 hydrogen ions must be consumed (eq. 2), so the net gain in equation is two hydrogen ions).

Although all pyrite probably oxidizes according to some combination of the above equations, it does not all react at the same rate. Clark (1965) found that sedimentary-type pyrite, which is found in coal, is more easily oxidized than other forms of pyrite due to its rapid reaction rates. More specifically, framboidal pyrite, which is often found in coal and associated overburden, is more reactive to oxidative weathering processes than coarsely crystalline forms due to its extremely fine-grained nature (Caruccio, 1970).

Although the sulfuric acid generated by oxidation of pyrite is an environmental hazard in itself, it is not the acid, but the metals released directly and indirectly by the oxidation process that are of direct consideration in this study. Trace elements are present as impurities within the pyrite and are released as the pyrite weathers (Harper, 1977; Blumthal, 1977). The sulfuric acid can also leach trace elements from overburden rocks disturbed by mining (Tedesco, 1980). Metals can be released by dissolving iron-manganese coatings from materials in the overburden, by leaching exchange ions from clays, by the dissolution of carbonate minerals and perhaps by attack on the octahedral layers of phyllosilicate minerals.

In spite of the fact that many previous reports have demonstrated relatively high metal concentrations in streams below coal mining operations, little is known about the fate of these metals during the transportation process. It is almost certain that there will be a decrease in concentration of metals with downstream transport as a result of a variety of factors, such as an influx of uncontaminated water from other streams, surface runoff or groundwater, by removal of the metals by precipitation or by adsorption of trace elements by stream sediments. Downstream changes in the chemistry of a stream can affect the behavior of metal ions in solution. The predictability of the behavior of metal ions in a natural stream is complicated by a myriad of potential complexing agents, including organic ligands (molecules), hydroxides, or clays (Stumm and Morgan, 1970). The resulting combinations of metals with such substances may form new, chemically stable compounds or may result in temporary adsorption processes that remove metals from the stream water.

In the natural environment, all sorts of living and decaying organic materials are present in streams and organic materials are brought in from nearby soils, contributing a host of organic molecules to the water. The presence of organic ligands can account for the occurrence of higher concentrations of metals in natural waters than theoretical inorganic solubility product calculations would predict (Stumm and Morgan, 1970). Reuter and Perdue (1977) demonstrate that even very small amounts of organics in water can significantly affect metal solubilities. Sholkovitz and Copland (1981) demonstrated that such natural metal-organic complexes are stable in the pH range of 3 to 9, but decrease below that. On the other hand, organic ligands not only can increase the solubilities of some metals, but they can do the reverse and increase the attractive forces between metal ions and sediment when the organic materials are part of the sediment (Davis and Leckie, 1976). Stumm and Morgan (1970) have argued that soluble organic chelates are not prevalent in natural waters, because metal ions typically precipitate out of solution as hydroxides, taking along chelating organic material. For example, ferric hydroxide serves to co-precipitate many types of organic acids (Millot, 1970), which could take out of solution organically complexed heavy metals.

Iron and manganese hydrous hydroxides/oxides have been frequently studied because of their influence on the precipitation of other metals. Jenne (1968) provides a review of the subject. Surface chemical controls such as provided by these oxides can remove heavy metals even from solutions that are undersaturated with respect to oxide or hydroxide solid phases. Although the sorption processes are usually pH dependent, heavy metals can be removed at lower pH than would occur otherwise (James and MacNaughton, 1977). Ferric and manganese hydrous oxides and hydroxides serve as redox substrates and substitution sites for the co-precipitation of many metals, such as chromium, cobalt, copper, nickel and zinc. Some sediment and oxide studies have reported lead as well (Carpenter et al., 1971). Nonmetals, such as arsenic, may also co-precipitate with ferric hydroxide (Crecelius, 1975). Shallow surface waters tend to increase the oxidation of iron due to the presence of oxygen (Hem, 1970). Flocculated iron hydroxides slowly settle out, and can become concentrated in deeper waters where they have had a chance to settle (Sundby and Loring, 1978). During their passage through the water, such flocs have the opportunity to scavenge heavy metals. Given enough time, the flocs will ultimately settle to the bottom and become incorporated into the stream sediment, where they can remain as part of the mud or form coatings on sedimentary particles.

Clay minerals can also remove heavy metals from natural waters. Adsorption can take place onto small quantities of clays, even in the presence of much larger quantities of alkaline earth ions (O'Connor and Kester, 1975). Altered clays, those coated with organic substances or more importantly aluminum or iron hydroxides, have been shown to be very effective removal agents for cadmium (Levy and Francis, 1976).

Because hydrous iron and/or manganese flocs and clay minerals both occur in small grain sizes, one would expect to see a relationship between grain size and heavy metal content in stream sediment. Indeed this is the case. Iron and manganese contents of sediments increase with decreasing grain size, as would be expected (Nota and Loring, 1965). Metal ions in general have greater affinities for clay-size particles rather than sand-size grains (Whitney, 1975). Other size-affinity relationship studies show that non-metals, such as arsenic, also have greater affinities for clay-size particles than for sand (Ruppert et al., 1974).

In summary, there is an abundance of literature suggesting that metals transported by streams frequently end up in the sediments, especially fine-grained sediments, through a variety of precipitation and sorption processes. This should also hold true for metals released through coal mining activities. The purpose of this study is to examine the stream sediment of a coal mining area in order to determine if there are anomalous concentrations of metals that are attributable to coal mining and, if so, to examine the general geochemical factors that govern the distribution of the metals in the streams below the mines.

SECTION 5

EXPERIMENTAL METHODS

FIELD PROCEDURES

Regional Study

In the regional part of this study, a method was needed to give broad coverage to the stream sediment sampling. To do this, it was decided to collect the sediment samples at the intersections of county/state roads with perennial streams. Because the stream drainages are dendritic in the area and roads are roughly rectilinear in position, a reasonably uniform sampling density can be attained. However, some bias is introduced into the sample set in favor of mid-size streams, because the smallest ditches were ignored and the largest streams are not bridged as frequently.

Each sample was collected upstream from the bridge or culvert indicated as the sample location in order to reduce possible contamination by human activities along the road. Many such areas have trash of various sorts in the stream at stream/bridge intersections and, by choosing an upstream area in which to sample, the effects of such material was minimized. Each sample was a composite of three or more grab samples taken within a ten meter reach of the stream; all samples were taken from the middle of the stream, taking care to avoid slumped bank material. Streams were normally waded and sediment collected with aluminum samplers; however, in areas where a stream was unwadable, the samples were collected with a device consisting of an aluminum container affixed to the end of an aluminum pole. In the case of rivers and in times of flood when entry into the stream was impossible, the samples were collected from the bridge itself using an Eckman dredge. Samples were taken of the material within three centimeters of the sediment-water interface to reduce any variations that might be caused by changes in Eh or pH with sediment depth.

Overburden Study

Overburden materials were collected by channel sampling individual lithological units at the active faces of coal mines. Samples were removed using rock hammers, small sledge hammers and chisels. They were stored in plastic sample bags for return to the laboratory.

Detailed Stream Study

Water samples were collected at the mid-point of streams, about 15 cm. below the surface, wherever this was physically possible. In those instances where it was not possible to sample at that position in the stream, the samples were collected as close to it as possible. The water samples were collected in 250 ml. polyethylene bottles that had previously been washed, soaked in concentrated HCl and thoroughly rinsed in distilled, deionized water. Each sample was spiked with 5 ml. of concentrated nitric acid. The pHs of the streams at the collection sites were measured using a Corning Model 6 portable pH meter.

During our detailed study of three streams, samples were collected at the same sites at two week intervals over a one-year period. The field procedures used in this part of the study were identical to those described above, except that in some instances the collection sites were not at road/stream intersections.

LABORATORY PROCEDURES

The stream sediment samples for both the regional and detailed stream studies were brought into the lab, emptied into aluminum pans, and dried in an oven at 60° C for approximately 48 hours. They subsequently were disaggregated in a porcelain mortar and pestle to break up lumps of clayey material that formed during drying. The disaggregated sediment samples were then sieved to -80 mesh using polyethlene sieves and the coarse fraction discarded. The -80 mesh size fraction is widely used for stream sediment geochemical prospecting studies, because the fine-grained materials have been shown to contain the highest concentrations of adsorbed metals.

The following hot HCl leaching technique was used to extract the trace elements from the stream sediment samples and from the overburden samples.

(1) Dry approximately 15 grams of sample at 105° C until constant weight is obtained.

(2) Weigh out a 10 gram portion to the nearest 0.0001 gram in a 250 ml beaker.

(3) Add 50 ml. of 0.3M hydrochloric acid, mix and heat to just below boiling (95° C) on a hot plate for 30 minutes.

(4) Filter through a Whatman no. 42 filter paper (or equivalent) and collect the filtrate in a 250 ml beaker by the following method:

   (a) After heating, mix and let the sample settle. Decant the liquid through the filter paper.

   (b) Add 10 ml of 0.3M HCl to the beaker, mix, let the sample settle, then decant the liquid through the filter paper again.

   (c) Add 10 ml of 0.3M HCl to the beaker, mix, and filter.

(5) Cool the filtrate and transfer to a 100 ml volumetric flask. Rinse the 250 ml beaker with 5 ml of 0.3 HCl and pour into the volumetric flask.

(6) Dilute to volume with 0.3 HCl and store in clean polyethylene bottle.

Leachates and water samples were analyzed for arsenic, cadmium, cobalt, chromium, copper, iron, manganese, nickel, and zinc, using a Perkin-Elmer Model 603 atomic absorption spectrophotometer. Standard absorption techniques were used for all elements except arsenic, which required the attachment of a hydride generation system which volatilizes arsenic for concentration measurement. Not all of these elements were used in all parts of the study.

Approximately three percent of the samples were randomly selected, spiked, and duplicated during the analysis stage to check for system and procedural accuracy and precision. Spikes were prepared by taking 10 ml. of the leachate and replacing 0.01 ml. of the sample with a 100 ppm spike solution. Thus, there was sufficient spike added to increase the concentration of the selected element by 1.0 ppm. Approximately three percent of the sediment samples were also duplicated at the preparation stage by selecting a sample from one single location and then leaching two separate 10 g. portions of the sample. In addition, approximately 3 percent of all samples were spiked at the preparation stage. Detailed results of these quality control procedures, the results of which were deemed quite satisfactory, are given in theses by Delfino (1979), Chruscicki (1980) and Tedesco (1980).

SECTION 6

REGIONAL DISTRIBUTION OF METALS IN STREAM SEDIMENT

STUDY AREA

In order to determine the broad geochemical patterns of metals in the stream sediments of southern Illiinois, a set of samples was collected at a sample density of approximately one sample every five square kilometers. The sampling effort covered most of the six counties in the study area. Specifically, the region sampled included the South and Middle Forks of the Saline River, Eagle Creek, Crab Orchard and Pond Creeks (both tributary to the Big Muddy River), Beaucoup Creek and the Little Muddy River (both tributary to the Big Muddy River on the north), Marys River, plus a few small creeks tributary to the Kaskaskia and Big Muddy Rivers collected to fill out areas around mining activities. Altogether, this is an area of about 5,500 square kilometers and is covered by nearly 700 samples (see Appendix A). The sample locations are shown on Figures 3 through 6.

As a means of showing the distribution of the various elements in the stream sediments of southern Illinois, a series of maps will be presented showing elemental concentrations within each of four areas. The following names will be used to describe these areas in the ensuing discussions. The term Saline River area will be used in reference to that part of the study area encompassing the South Fork and Middle Fork of the Saline River and the Eagle Creek drainage basins. The term Crab Orchard Creek area will refer to that part of the study area involving streams south of the Big Muddy River, including Crab Orchard Creek, Pond Creek, Bear Creek and several other small named and unnamed creeks. The term Beaucoup Creek area will refer to the Beaucoup Creek and Little Muddy River drainage basins. Finally, the term Marys River area will refer to the area west of the basin of Beaucoup Creek, involving mainly the Marys River area in Randolph County. Figure 7 illustrates the geographical relationships between the four study areas.

To aid in the visualization of the distribution of elements in the stream sediment, the following method was devised. First the median value of each metal within each of the four areas was determined. Values of twice and four times the median were calculated, and the samples were indicated to have less than twice the median value, between two and four times the median and greater than four times the median by use of increasingly larger solid circles on the maps.

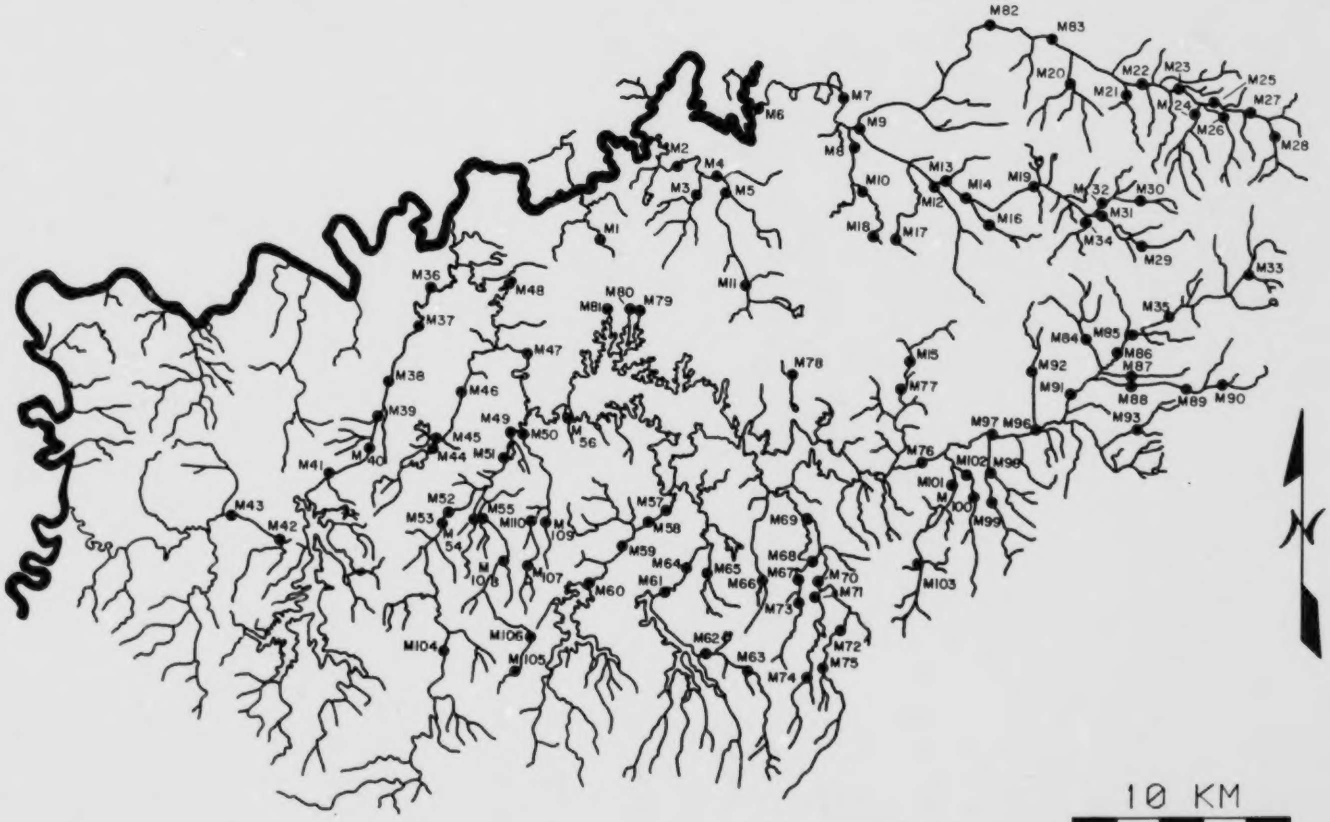

M82
M83
M20
M21
M22
M23
M24
M25
M26
M27
M28
M7
M6
M9
M8
M2
M4
M3
M5
M1
M10
M18
M17
M13
M12
M14
M16
M19
M32
M30
M31
M34
M29
M11
M33
M35
M36
M37
M48
M80
M81
M79
M47
M78
M15
M77
M84
M85
M86
M87
M88
M89
M90
M92
M91
M93
M38
M46
M39
M49
M50
M56
M45
M44
M40
M51
M41
M97
M96
M76
M101
M102
M98
M100
M99
M43
M42
M52
M53
M54
M55
M110
M109
M57
M58
M59
M69
M108
M107
M64
M65
M66
M61
M68
M67
M70
M71
M73
M60
M103
M62
M63
M106
M105
M104
M72
M75
M74
10 KM
N

Figure 3. Sample locations in the Crab Orchard Creek area.

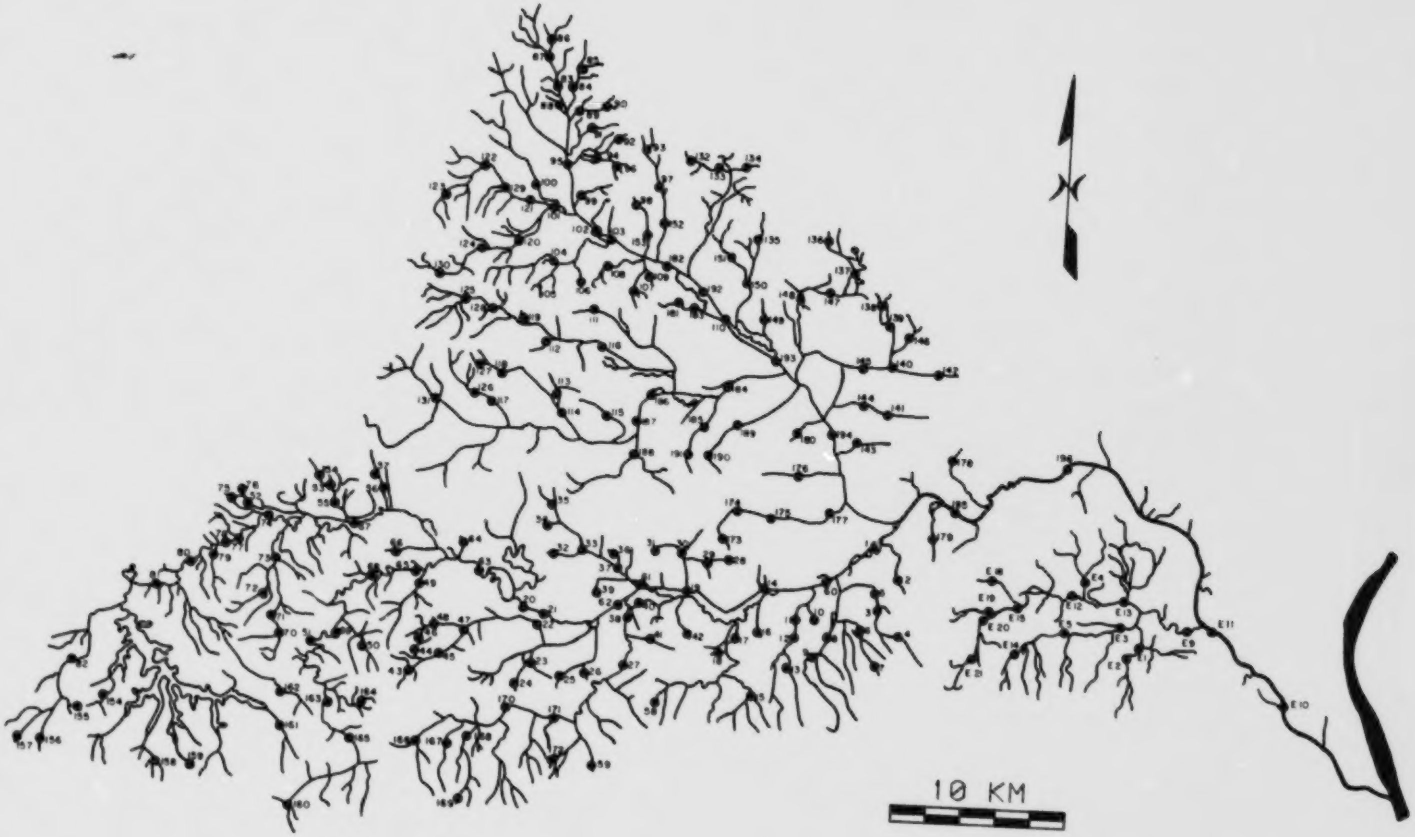


Figure 4. Sample locations in the Saline River area.

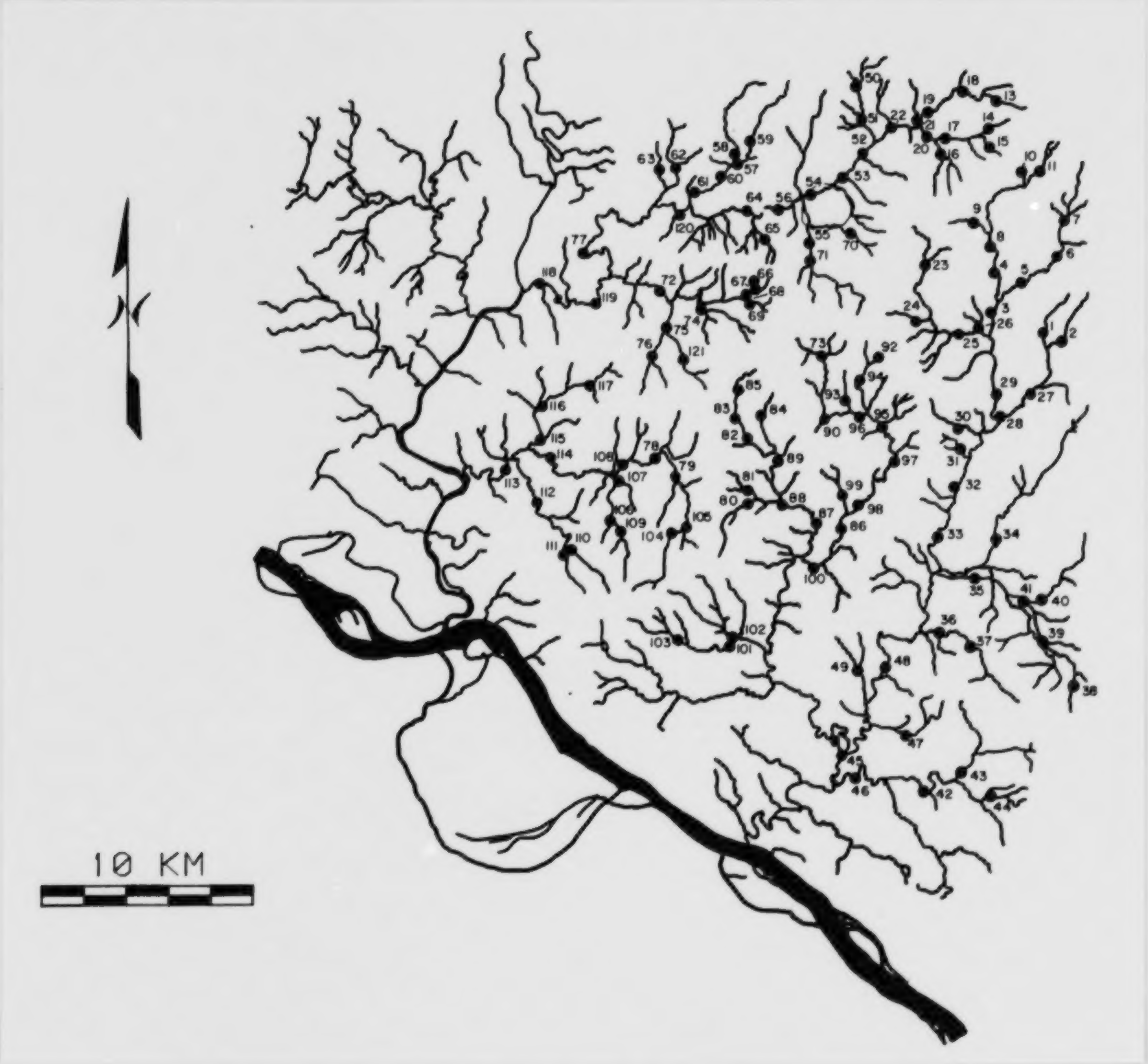
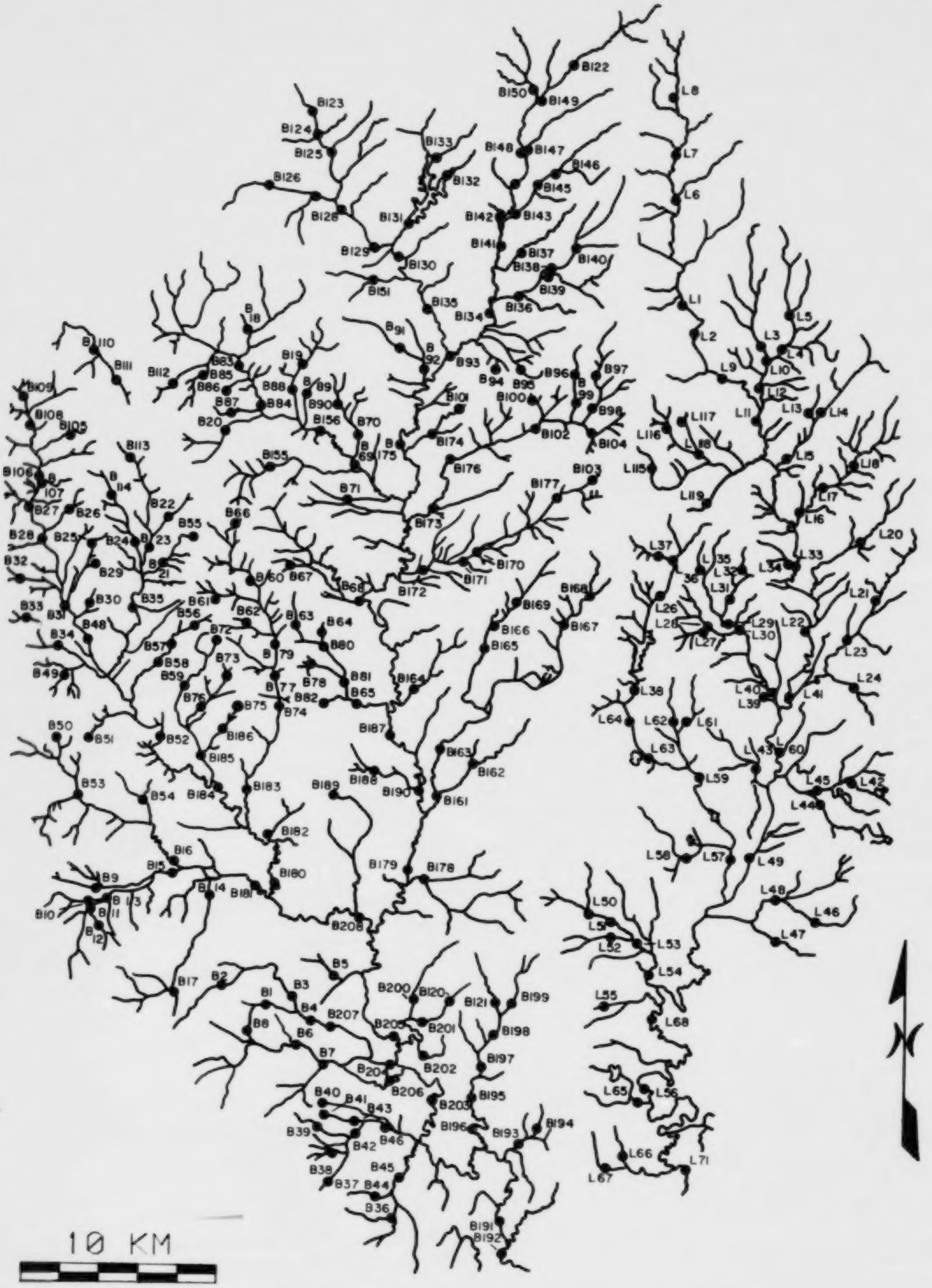


Figure 5. Sample locations in the Marys River area.


B122
B150
B149
L8
B123
B124
B125
B133
B148
B147
L7
B146
B126
B132
B145
L6
B128
B131
B142
B143
B141
B129
B137
B140
B130
B138
B139
B151
B135
B136
L1
B134
B18
B91
L2
L5
B110
B111
B92
B93
L3
L4
B112
B83
B19
B85
B94
B95
B96
B97
L9
L10
B86
B88
B89
B99
L12
B109
B87
B84
B90
B101
B100
L13
L14
B108
B105
B20
B156
B70
B98
L117
L11
B102
B104
L116
B113
B69
B175
B174
L18
B155
L115
L15
B106
B114
B107
B176
B103
B177
L119
L17
B27
B26
B22
B71
L16
B55
B66
B173
B28
B25
B24
B23
L20
B21
L37
L35
L33
B32
B29
B60
B67
B170
L34
B171
L32
B30
B33
B35
B61
B68
B172
L31
L21
B56
B168
L26
B31
B62
B63
B64
B169
L28
L29
L22
B48
B72
B166
B167
L27
L30
B34
B80
B165
B57
B58
B73
B79
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B49
B59
B78
B81
L24
B76
B77
B164
L40
L41
B82
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B74
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B16
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B179
B178
L58
L57
L49
B9
B180
B13
B14
B181
L48
B11
L50
L46
B10
B12
B208
L51
L52
L53
L47
B5
L54
B17
B2
B3
B200
B120
B121
B199
B1
B4
B207
L55
B8
B205
B201
B198
B6
L68
B7
B197
B204
B202
B40
B41
B206
B195
L65
L56
B43
B203
B39
B196
B193
B194
B46
B42
L66
L71
B38
B45
L67
B37
B44
B36
B191
B192
10 KM

Figure 6. Sample locations in the Beaucoup Creek area.

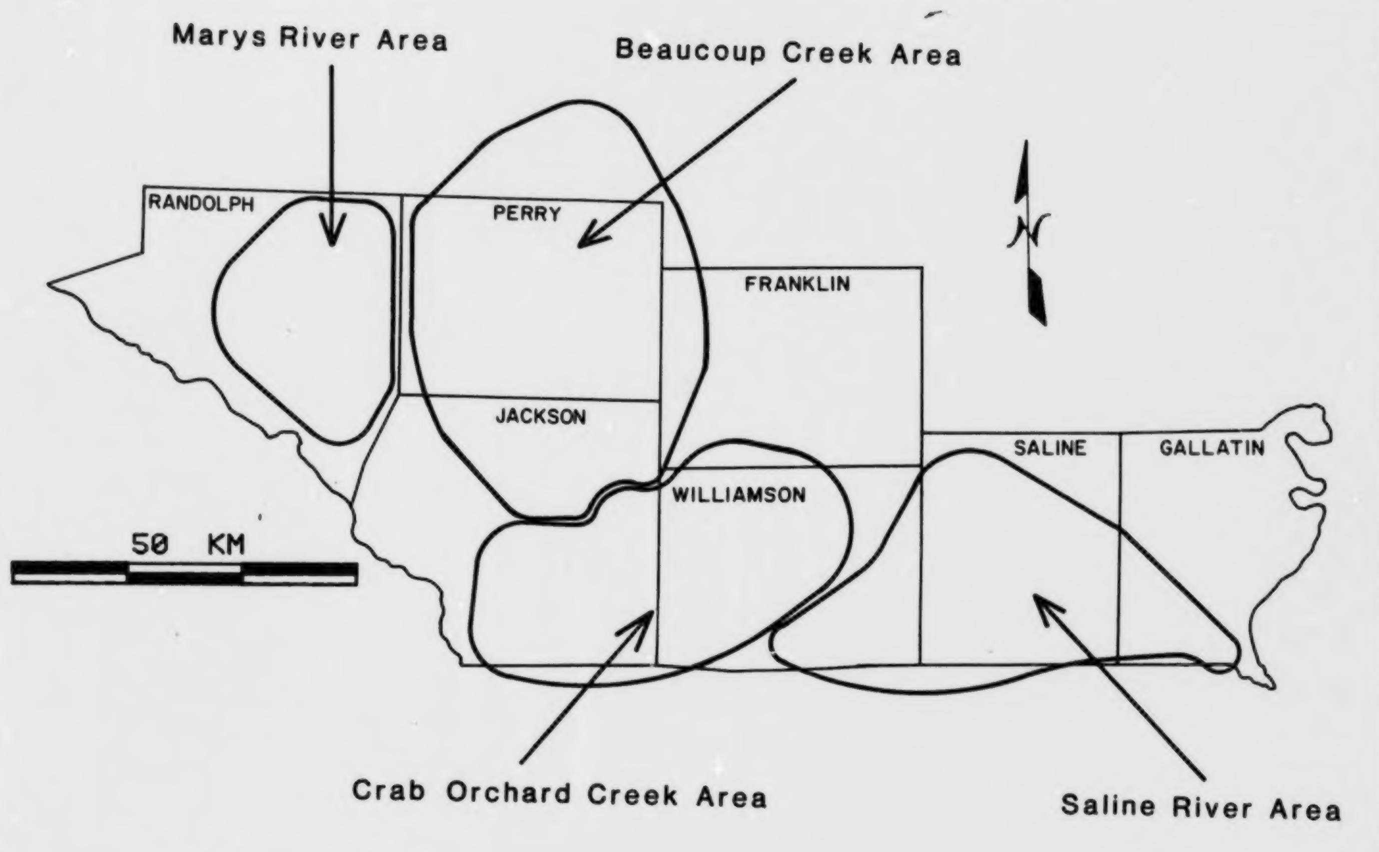

Marys River Area
Beaucoup Creek Area
RANDOLPH
PERRY
FRANKLIN
JACKSON
SALINE
GALLATIN
WILLIAMSON
50 KM
Crab Orchard Creek Area
Saline River Area

Figure 7. Geographical relationships between the four study areas.

ELEMENTAL DISTRIBUTION

The regional distribution of metals within the study area will be discussed on an element by element basis.

Cadmium

In the Saline River area (Figure 8), there are numerous high cadmium values in the stream sediments. Most of these are concentrated along the South Fork with another area of concentration in Eagle Creek. Two high values were noted in the westernmost part of the area; these occur downstream from a coal-fired powerplant. Another cluster of high values occurs in the northeast part of the basin, associated with underground coal mines in the area. In the Crab Orchard Creek area (Figure 9), numerous high values of cadmium occur. As before, clusters of high points are located downstream from coal mining activities. A pair of high values occurs in the southern part of the area. Although no mining is presently taking place in that area, several small and very old mines are scattered around the hills, and it is possible that these two points are downstream from one or more of these unmapped mines. Not shown on the map are several underground mines in the central part of the area. Several of the high values are below the old underground mines. In the Beaucoup Creek area (Figure 10), only four scattered, high cadmium values occur and three of these are clearly associated with strip mines. The fourth occurs in the northernmost part of the area and does not appear to be related to mining activities. In the Marys River area (Figure 11), several high values are present. Virtually all of these are adjacent to or downstream from mines.

Copper

In the Saline River area (Figure 12), only a few anomalously high copper values occur. Of these, two are downstream from a known gob pile, one is adjacent to a strip mine and the fourth is not known to be related to mining. Three high values occur in the Crab Orchard Creek area (Figure 13). The first is several kilometers downstream from mines; however, there are many low values between it and the mines. The other two are scattered and appear unrelated to mines. The two high concentrations which appear in the Beaucoup Creek area (Figure 14) are scattered and are spatially unrelated to mining. Finally, in the Marys River area (Figure 15), no high values occur, although a few scattered intermediate values showing no relationship to mining were noted.

Cobalt

In the Saline River area (Figure 16), six high cobalt values are present. One of these, located in the north center portion of the area, is in the vicinity of an old gob pile and is likely related to it. A second is located near the mouth of Eagle Creek, a stream contaminated by mining, while a third, in a tributary of the Saline River, receives drainage from a mining area. Two anomolously high values do not appear to be spatially related to coal mining. In the Crab Orchard Creek area (Figure 17), there are four more high values. Three of these locations are downstream from mining activities; however, the fourth cannot be explained in this manner. In the Beaucoup Creek area (Figure 18), three high values occur in the northern part of the area but appear to be unrelated to mining. Lastly, in the Marys River area (Figure 19), the one high value is in close proximity to a strip mine, but is upstream from the mining activity.

Iron

In the Saline River area (Figure 20), only three exceptionally high iron values occur. Two are downstream from mines while one is not. Several intermediate concentrations are located downstream from mining activities. In the Crab Orchard Creek area (Figure 21), a few high values are present, all of which occur downstream from coal mines. No exceptionally high values occur in the Beaucoup Creek area (Figure 22) or in the Marys River area (Figure 23).

Manganese

In the Saline River area (Figure 24), four high values of manganese occur in scattered locations, three of which occur downstream from coal mines. If intermediate values are considered, only a few are downstream from coal mines. Seven high values occur in the Crab Orchard Creek area (Figure 25) and are mainly downstream from mines; intermediate values occur frequently. Five high values occur in the Beaucoup Creek area (Figure 26), although only two of these are downstream from mines. Intermediate values appear to be unrelated to mining. Finally, two high manganese values occur in the Marys River area (Figure 27). Both of these are adjacent to strip mines, but do not appear to be downstream from them. Intermediate values are randomly scattered across the entire area.

Nickel

It can be seen that most of the twenty anomalous concentrations of nickel in the Saline River area (Figure 28) and the Crab Orchard Creek area (Figure 29) are downstream from coal mining activities. In the Beaucoup Creek area (Figure 30) there are only two high values, one of which is downstream from a coal mine. In the Marys River area (Figure 31), there is only one high value but it is adjacent to a coal strip mining area.

Zinc

Zinc is similar in geochemistry to cadmium, and so it is not surprising that the distribution of these two elements is similar. High zinc values are present in the Saline River area (Figure 32), mostly downstream from strip mining or downstream from the coal-fired power plant that is located in the area. Other high concentrations occur in Eagle Creek, an area heavily impacted by mining. Another neighborhood with high zinc values is located near an old gob pile in the northeast part of the area. Many high values also occur in the Crab Orchard Creek area (Figure 33). With few exceptions, these are closely associated with mining. High values in the Beaucoup Creek area (Figure 34), with two exceptions, are also closely associated with mining. Lastly, the one high value of zinc found in the Marys River area (Figure 35) is downstream from a strip mine.

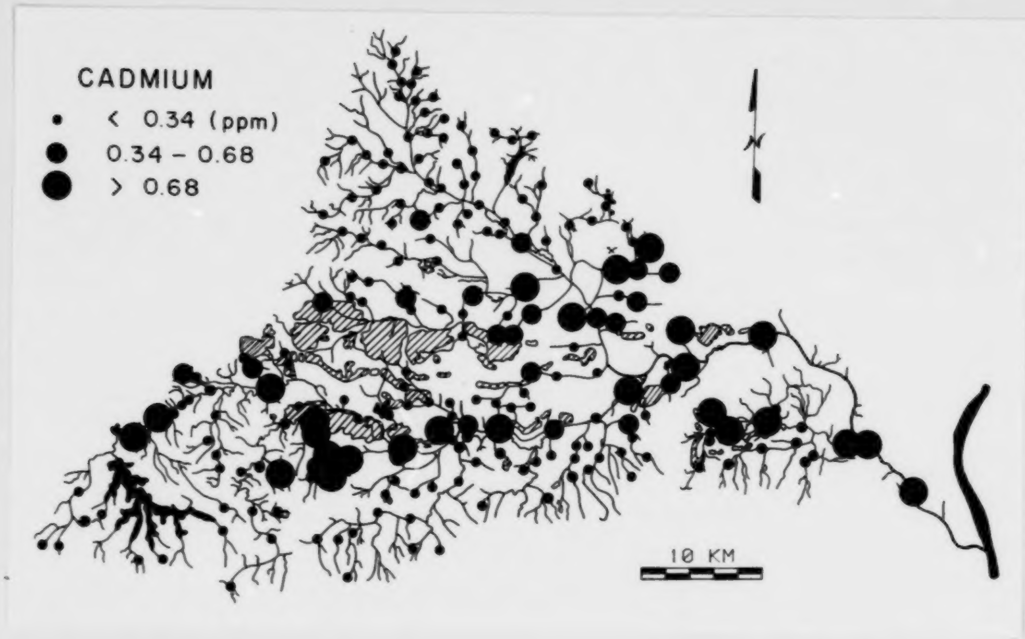

CADMIUM
< 0.34 (ppm)
0.34 - 0.68
> 0.68
N
10 KM

Figure 8. Cadmium concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

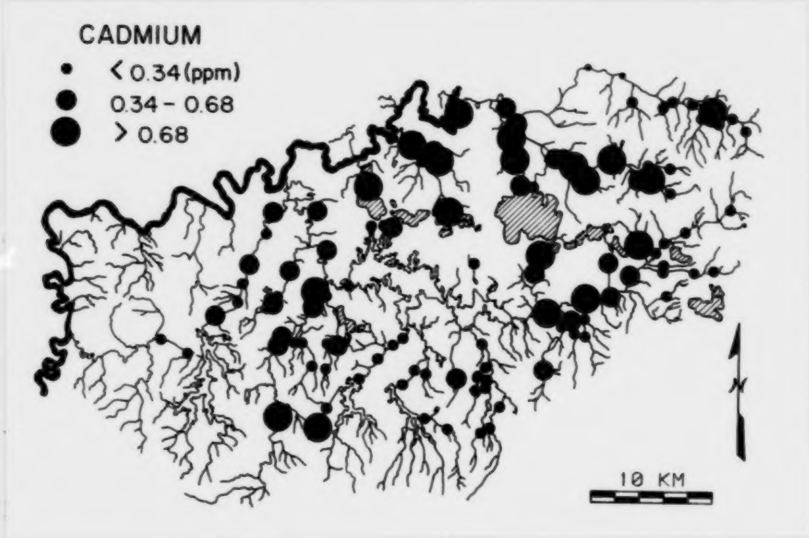

CADMIUM
< 0.34 (ppm)
0.34 - 0.68
> 0.68
N
10 KM

Figure 9. Cadmium concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

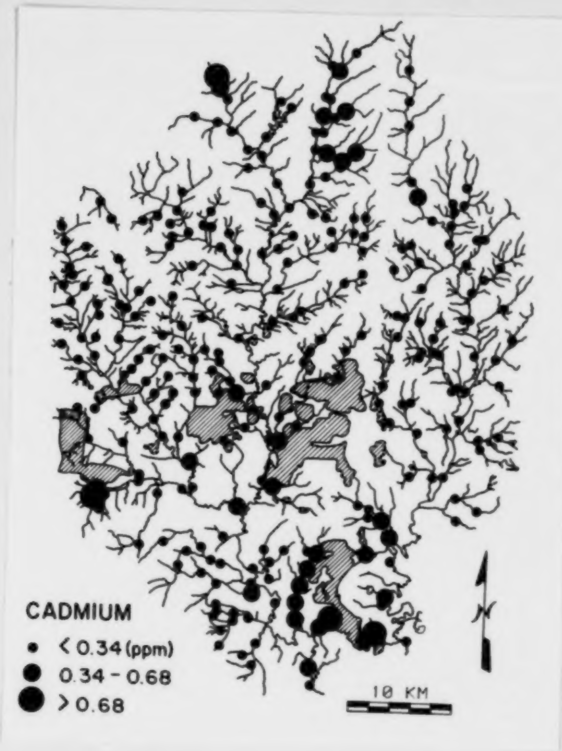

CADMIUM
• < 0.34 (ppm)
● 0.34 - 0.68
● > 0.68
10 KM

Figure 10. Cadmium concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

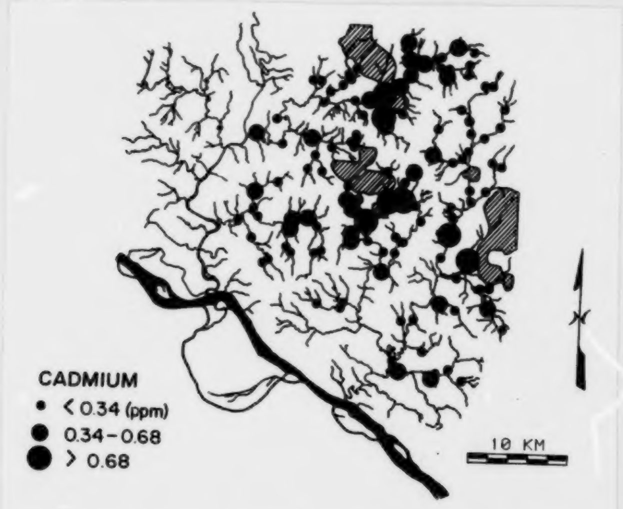

CADMIUM
• < 0.34 (ppm)
● 0.34-0.68
● > 0.68
10 KM

Figure 11. Cadmium concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

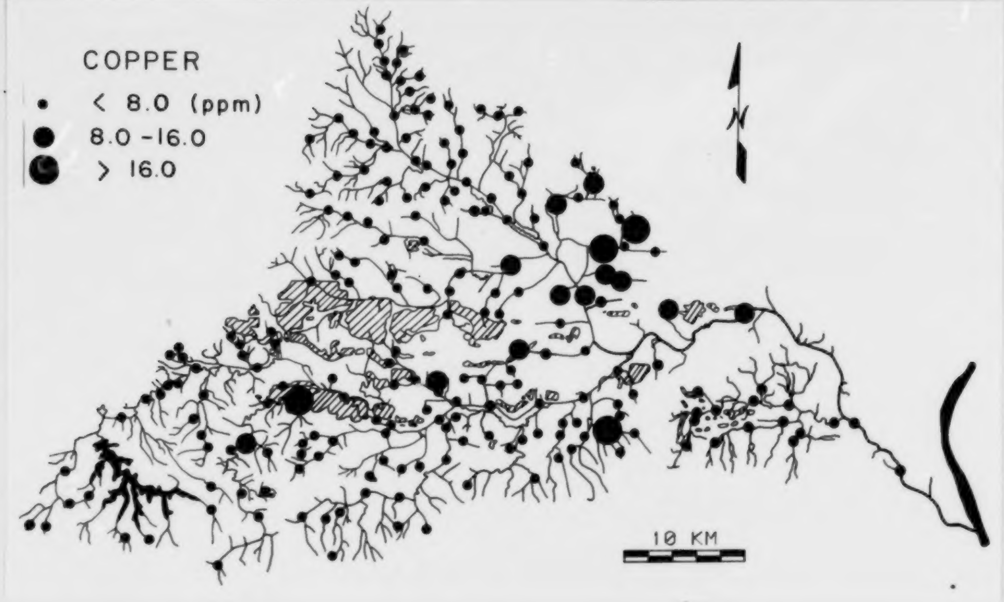

COPPER
< 8.0 (ppm)
8.0 - 16.0
> 16.0
N
10 KM

Figure 12. Copper concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

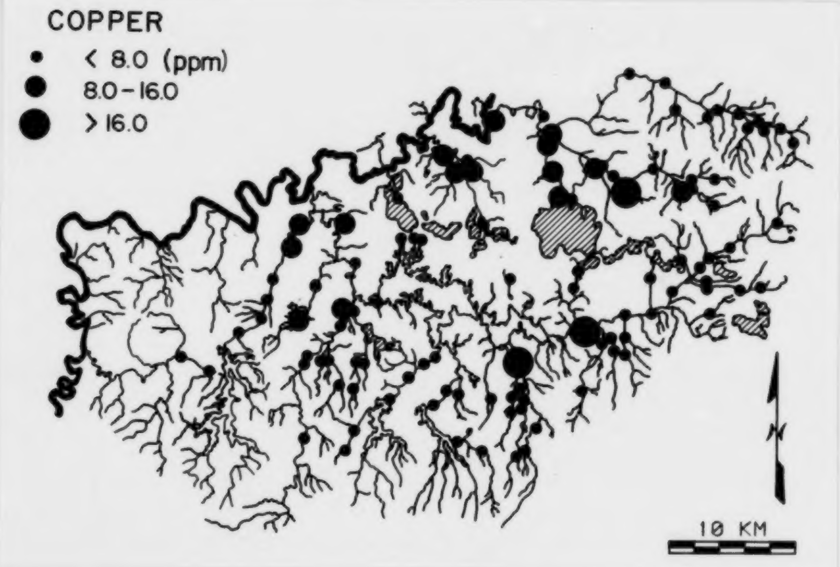

COPPER
< 8.0 (ppm)
8.0 - 16.0
> 16.0
N
10 KM

Figure 13. Copper concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

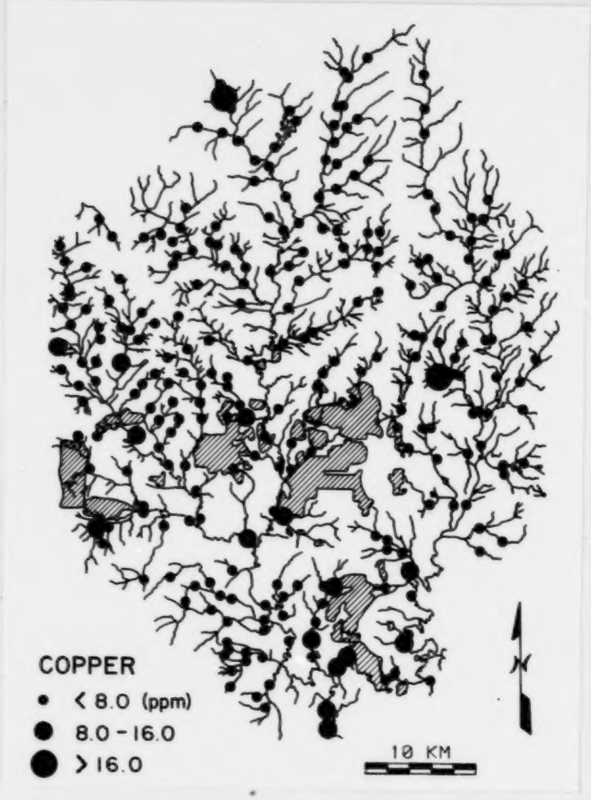

COPPER
• < 8.0 (ppm)
● 8.0 - 16.0
● > 16.0
10 KM
N

Figure 14. Copper concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

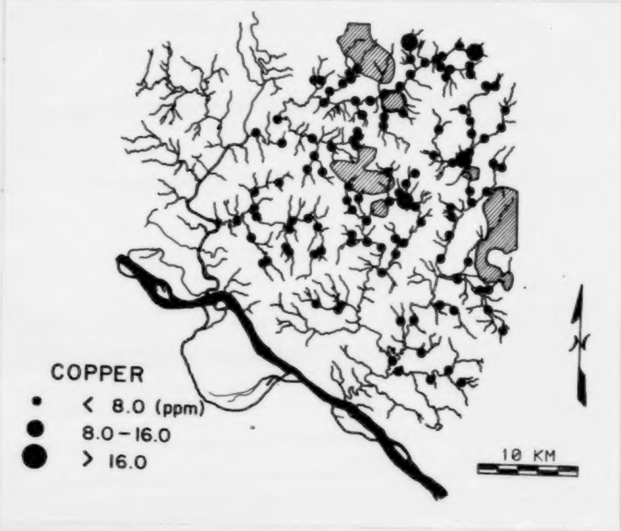

COPPER
• < 8.0 (ppm)
● 8.0 - 16.0
● > 16.0
10 KM
N

Figure 15. Copper concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

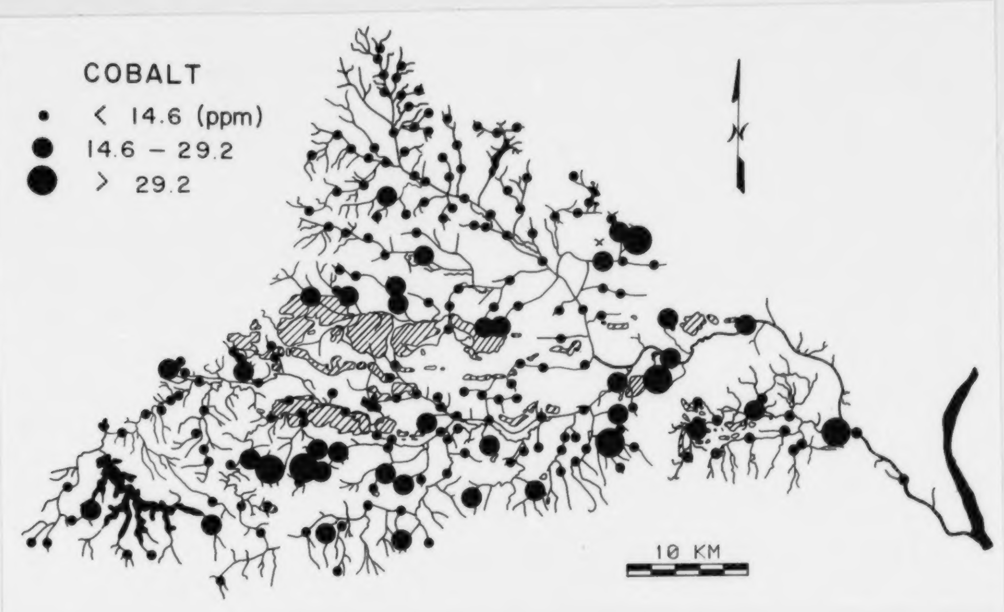

COBALT
• < 14.6 (ppm)
● 14.6 – 29.2
● > 29.2
10 KM

Figure 16. Cobalt concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

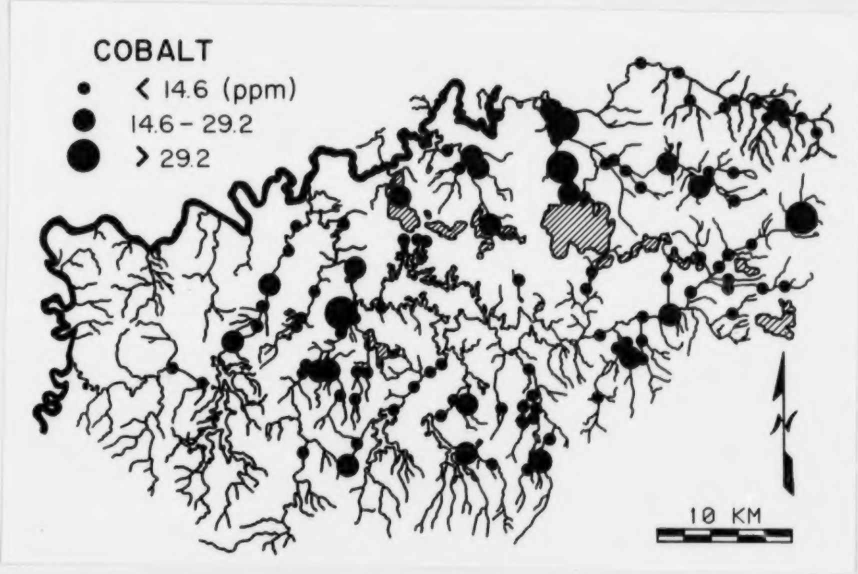

COBALT
• < 14.6 (ppm)
● 14.6 - 29.2
● > 29.2
10 KM

Fig 17. Cobalt concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

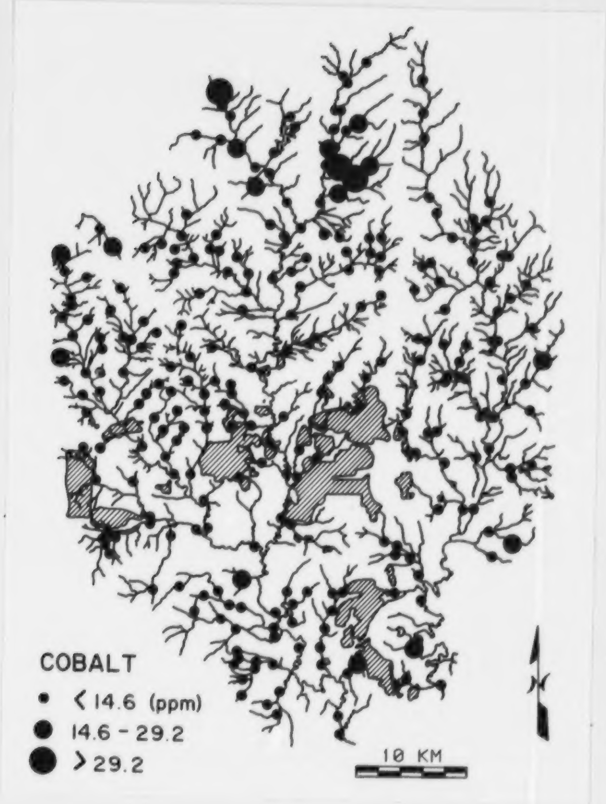

COBALT
• < 14.6 (ppm)
● 14.6 - 29.2
● > 29.2
10 KM

Figure 18. Cobalt concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

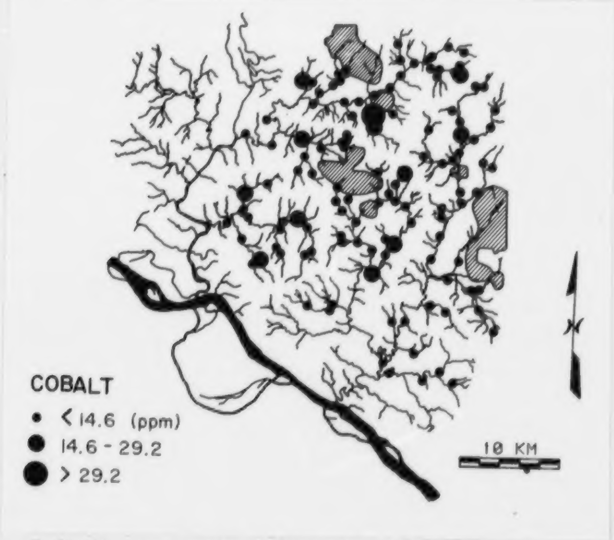

COBALT
• < 14.6 (ppm)
● 14.6 - 29.2
● > 29.2
10 KM

Figure 19. Cobalt concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

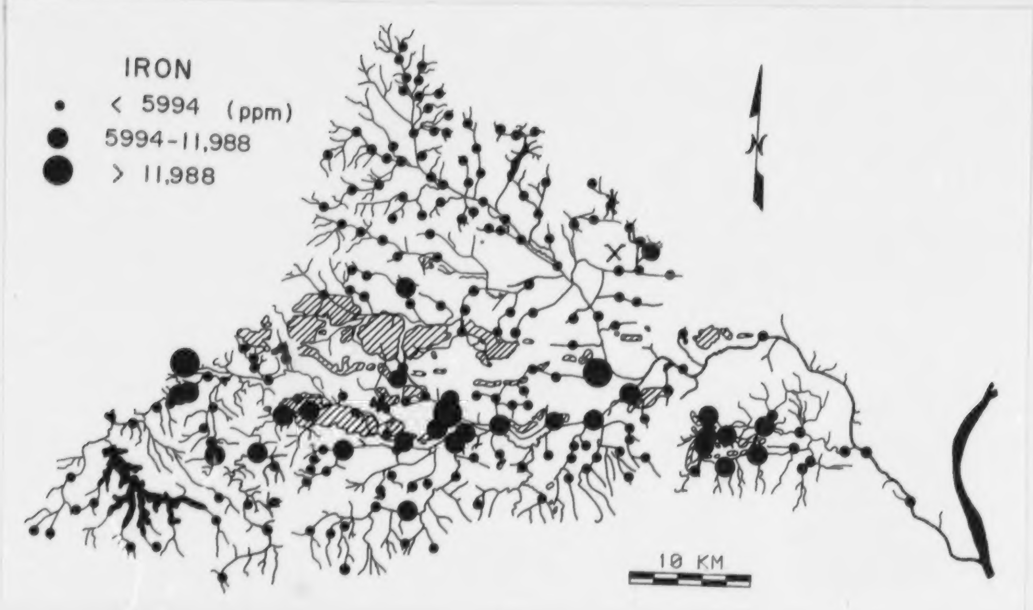

IRON
• < 5994 (ppm)
● 5994-11,988
● > 11,988
10 KM

Figure 20. Iron concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

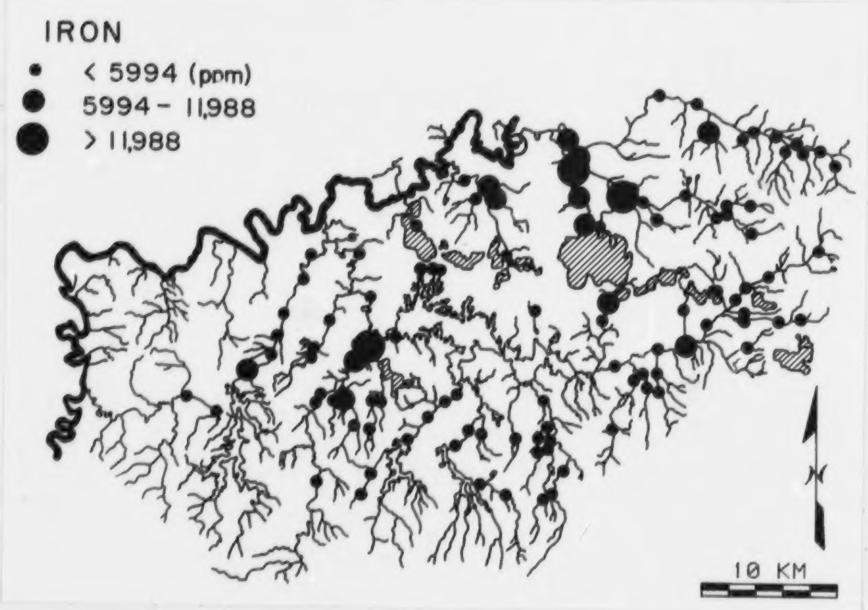

IRON
• < 5994 (ppm)
● 5994 - 11,988
● > 11,988
10 KM

Figure 21. Iron concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

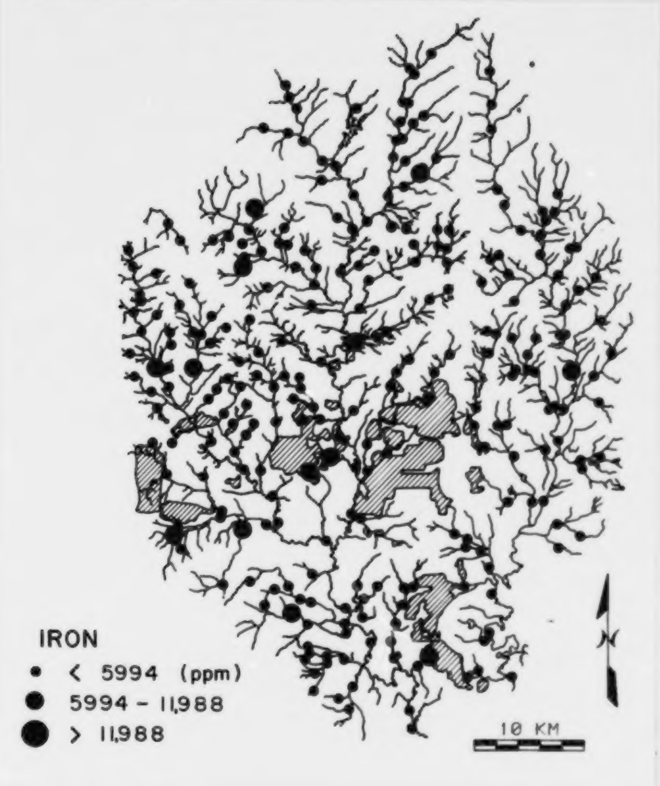

IRON
< 5994 (ppm)
5994 - 11,988
> 11,988
10 KM

Figure 22. Iron concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

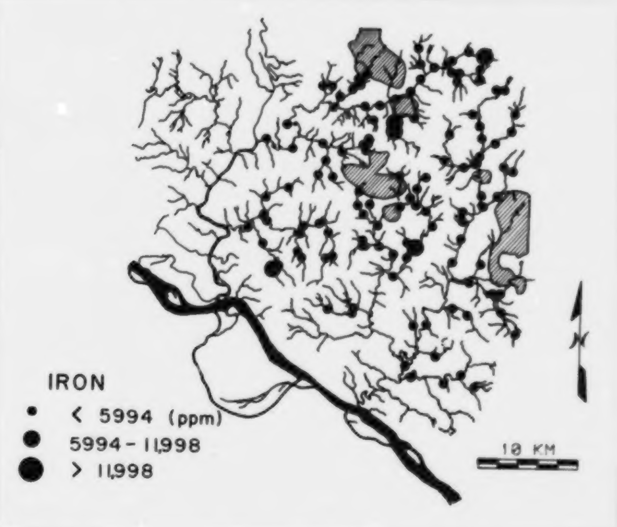

IRON
< 5994 (ppm)
5994 - 11,998
> 11,998
10 KM

Figure 23. Iron concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

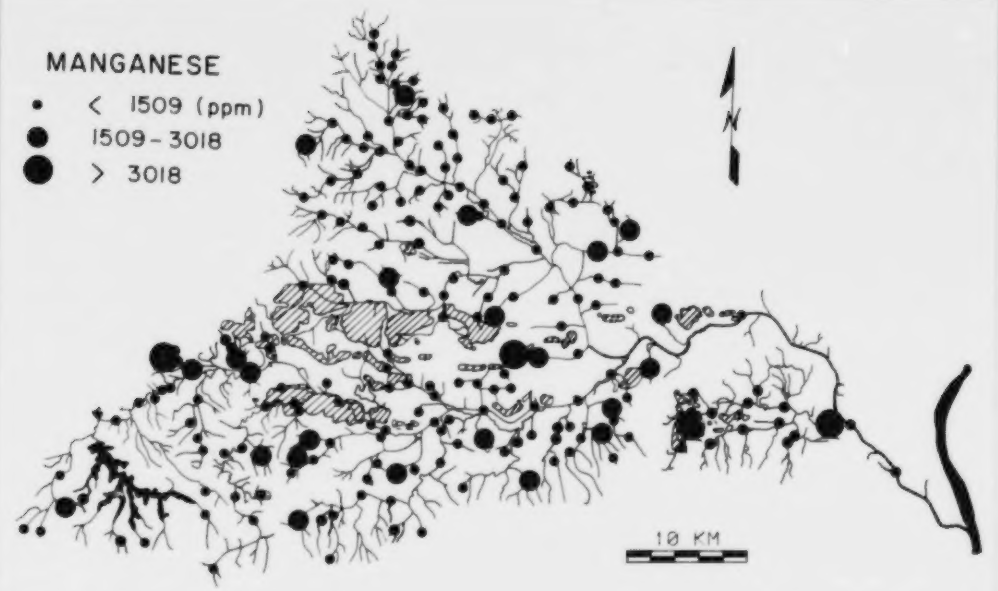

MANGANESE
< 1509 (ppm)
1509 - 3018
> 3018
N
10 KM

Figure 24. Manganese concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

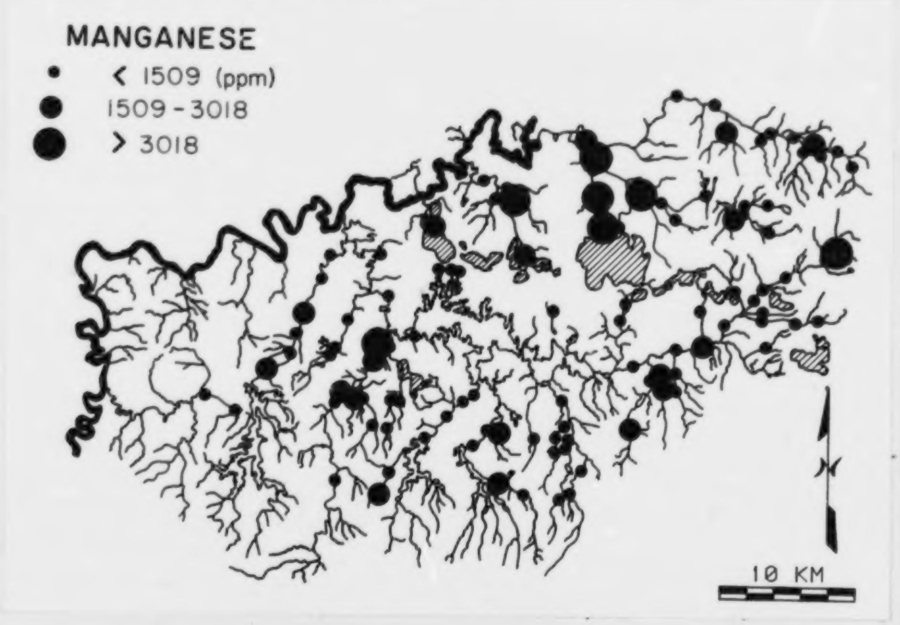

MANGANESE
< 1509 (ppm)
1509 - 3018
> 3018
N
10 KM

Figure 25. Manganese concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

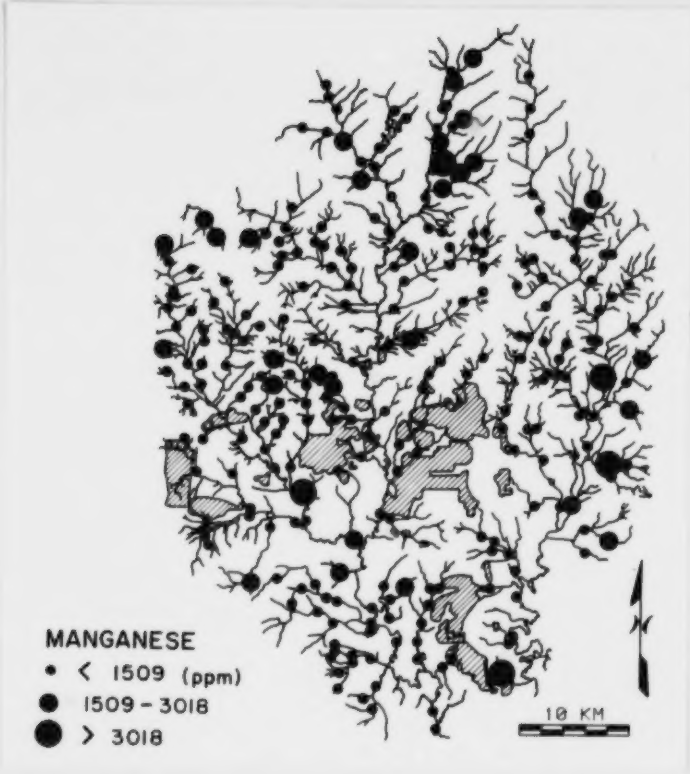

MANGANESE
< 1509 (ppm)
1509 - 3018
> 3018
10 KM

Figure 26. Manganese concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

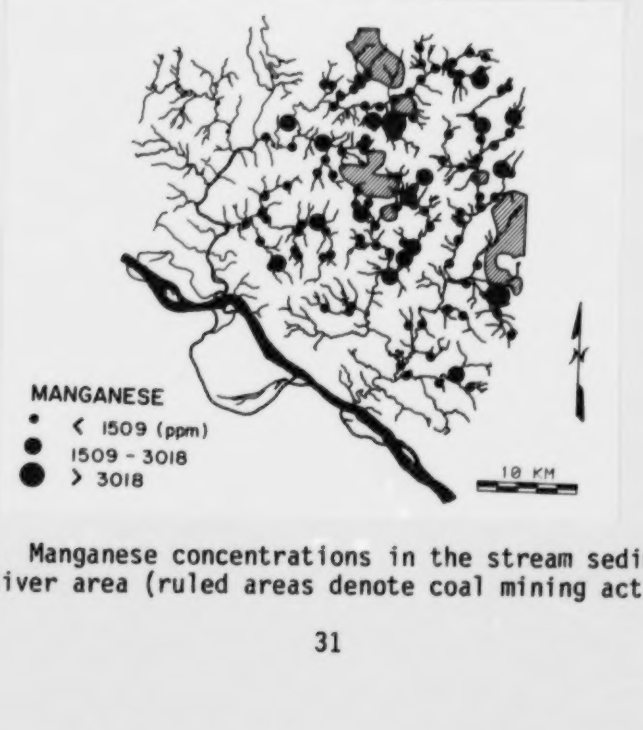

MANGANESE
< 1509 (ppm)
1509 - 3018
> 3018
10 KM

Figure 27. Manganese concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

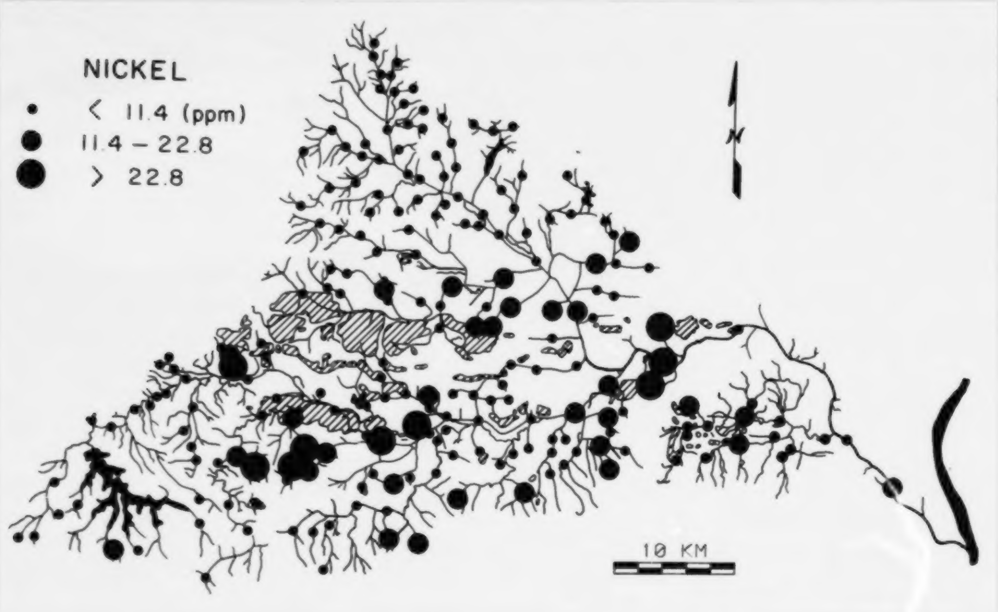

NICKEL
< 11.4 (ppm)
11.4 – 22.8
> 22.8
N
10 KM

Figure 28. Nickel concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

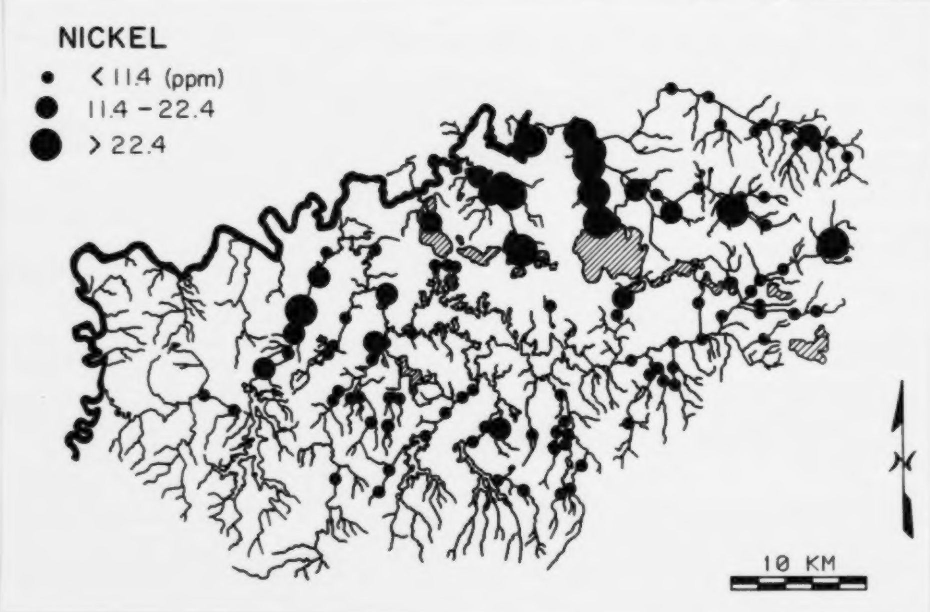

NICKEL
< 11.4 (ppm)
11.4 – 22.4
> 22.4
N
10 KM

Figure 29. Nickel concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

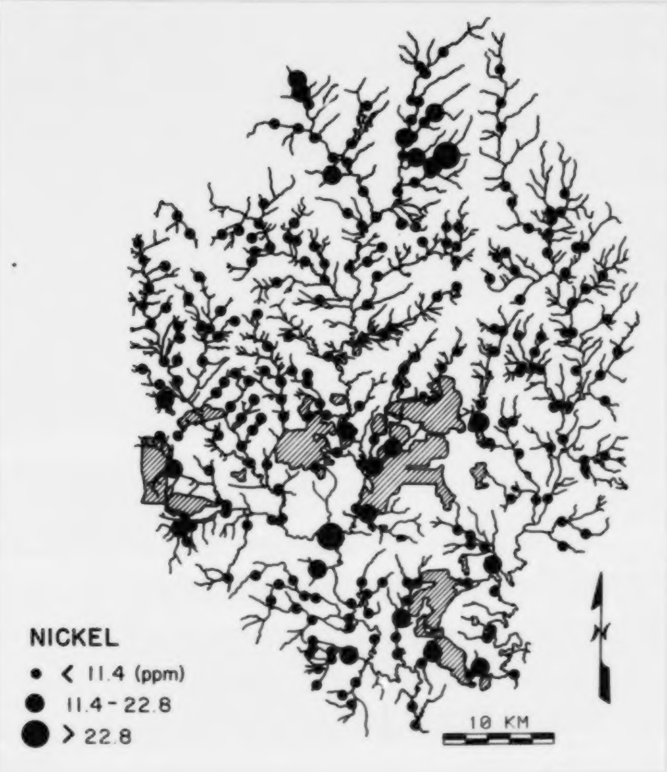

NICKEL
< 11.4 (ppm)
11.4 - 22.8
> 22.8
10 KM

Figure 30. Nickel concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

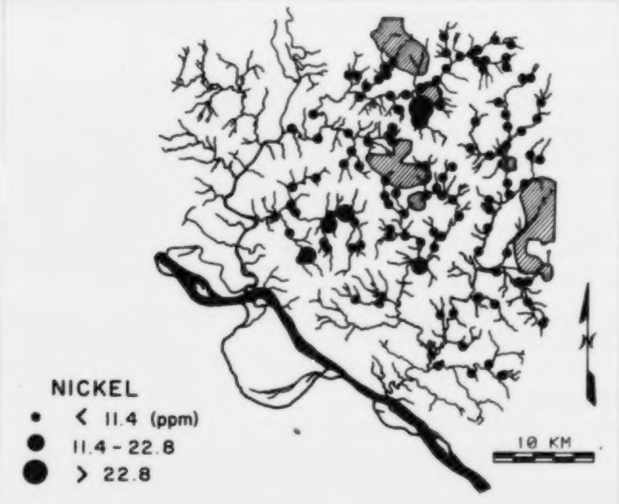

NICKEL
< 11.4 (ppm)
11.4 - 22.8
> 22.8
10 KM

Figure 31. Nickel concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

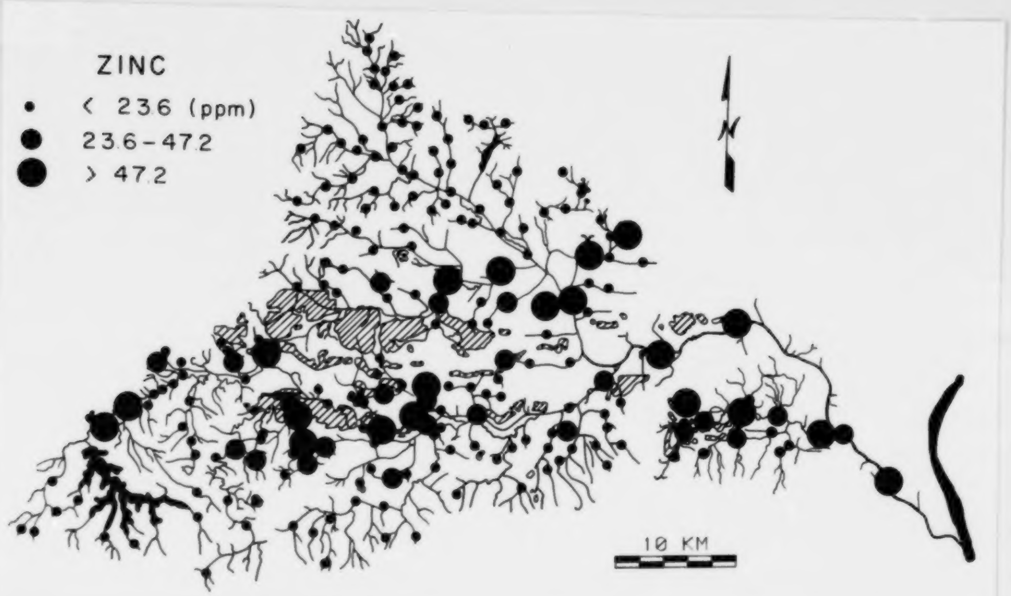

ZINC
• < 23.6 (ppm)
● 23.6-47.2
● > 47.2
10 KM

Figure 32. Zinc concentrations in the stream sediment of the Saline River area (ruled areas denote coal mining activity).

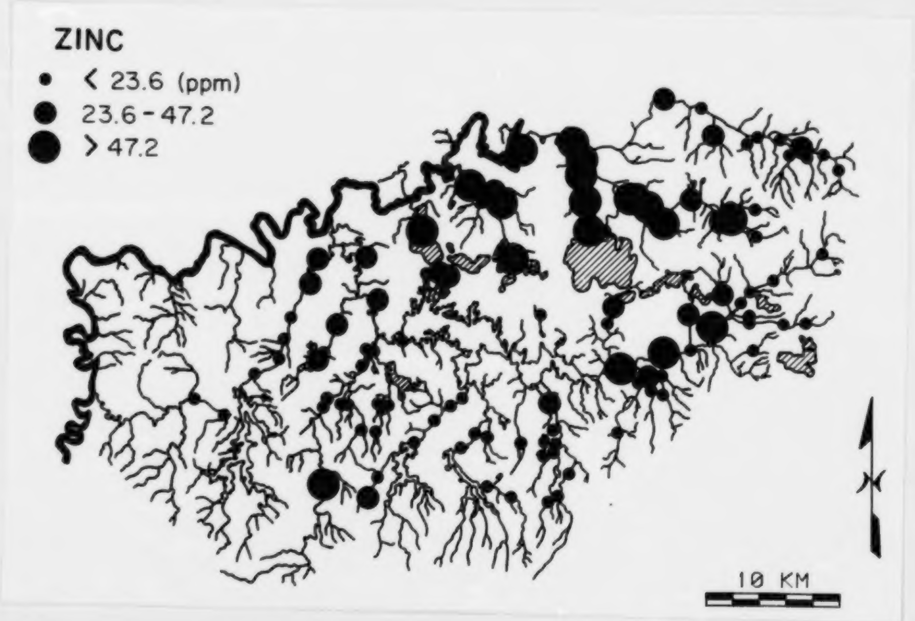

ZINC
• < 23.6 (ppm)
● 23.6 - 47.2
● > 47.2
10 KM

Figure 33. Zinc concentrations in the stream sediment of the Crab Orchard Creek area (ruled areas denote coal mining activity).

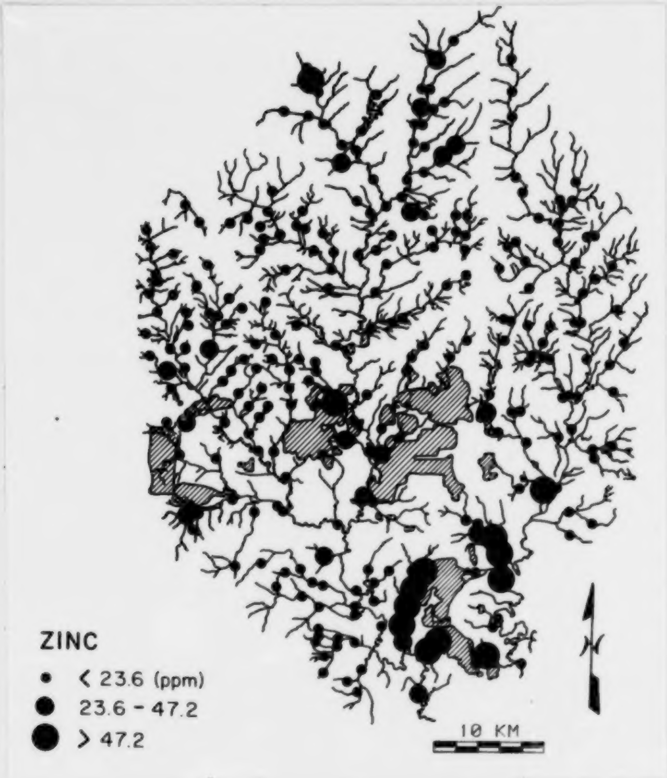

ZINC
< 23.6 (ppm)
23.6 - 47.2
> 47.2
10 KM

Figure 34. Zinc concentrations in the stream sediment of the Beaucoup Creek area (ruled areas denote coal mining activity).

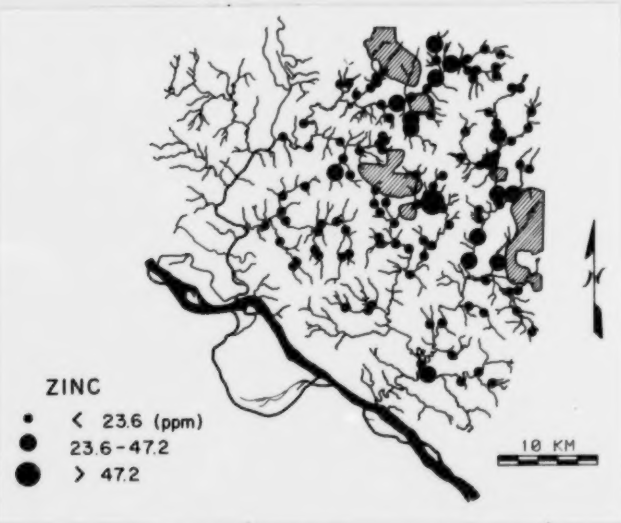

ZINC
< 23.6 (ppm)
23.6-47.2
> 47.2
10 KM

Figure 35. Zinc concentrations in the stream sediment of the Marys River area (ruled areas denote coal mining activity).

INTERPRETATION OF REGIONAL DISTRIBUTION OF METALS

Examination of the data shows two interesting features, i.e., there is a persistent association of high values of most metals with specific sample location and there is a marked change in the frequency of high values between the eastern and western parts of the state. The DuQuoin Monocline appears to be a feature that separates the two regions. This feature, it should be remembered, divides the region into a limestone-rich shelf area in the west and a shale-sandstone rich, deltaic area in the east.

A multiple linear regression was performed on the data for the various basins to see if there indeed is interelemental correlation (Tables 2 and 3). As pointed out above, the locations of high values for various elements consistently occurs at the same sampling sites, i.e., the same samples tend to have high values for various elements while other samples tend to have low values. Because of the differences seen from basin to basin, the data set was divided into two parts, one east of the monocline and consisting of the Saline River area and Crab Orchard Creek area samples and the other west of the monocline, consisting of the samples from the Beaucoup Creek area and the Marys River area.

One feature is very apparent from Tables 2 and 3. There is an excellent interelemental correlation both east and west of the DuQuoin Monocline. In the eastern area, there is correlation, significant at the 99% confidence level, between every element pair tested. West of the monocline, the same thing is true except for the pairs Fe-Cd, Mn-Cu, and Mn-Zn. This confirms the visual observation that the samples that were high for one element tend to be high for all of the elements.

Another feature that appears when these data sets are examined is that there tend to be more high values of concentration east of the DuQuoin Monocline than west of it. The mean values determined in the interelement correlation study tend to bear out this observation, but to more thoroughly confirm it the data were statistically analyzed using standard Z-test procedures.

First, interbasin comparisons were run for each individual element and significant differences were found when areas east of the DuQuoin Monocline were compared to areas west of it; however, significant differences were not generally observed when comparing areas on the same side of the structure. Next, the mean value for all samples was compared to the values for the individual areas and, once again, the data split into the same two geographical groups. Finally, the areas were grouped into those east of the Monocline (Saline River area and Crab Orchard Creek area) and those west of it (Beaucoup Creek area and Marys River area) and these were compared to each other (Table 4). The results of these tests indicate that there is no significant difference between the areas for the elements copper and manganese. However, for all of the other elements tested (Cd, Co, Fe, Ni, and Zn), the eastern group is significantly higher in value.

TABLE 2. MEANS, STANDARD DEVIATIONS AND INTERELEMENT CORRELATION COEFFICIENTS FOR THE SALINE RIVER AND CRAB ORCHARD CREEK AREAS

Means

Cd	Co	Cu	Fe	Mn	Ni	Zn
0.4014	10.626	4.754	3969	992.3	9.242	27.09

Standard deviations

0.6633	8.006	3.677	2790	1038	10.50	37.96

Correlation coefficients

	Cd	Co	Cu	Fe	Mn	Ni	Zn
Cd	1.0000	0.3230**	0.3333**	0.2718**	0.2323**	0.5766**	0.7802**
Co	0.3230**	1.0000	0.2946**	0.2119**	0.6872**	0.6469**	0.4182**
Cu	0.3333**	0.2946**	1.0000	0.2460**	0.1802**	0.3132**	0.4190**
Fe	0.2718**	0.2219**	0.2460**	1.0000	0.3043**	0.2629**	0.3243**
Mn	0.2323**	0.6872**	0.1802**	0.3043**	1.0000	0.4523**	0.3382**
Ni	0.5766**	0.6469**	0.3123**	0.2619**	0.4523**	0.0000	0.7072**
Zn	0.7802**	0.4182**	0.4190**	0.3243**	0.3382**	0.7072**	1.0000

Number of samples = 313. Critical values of 'r' are: 95% level = 0.111, 99% level = 0.146

* Significant at the 95% confidence level.

** Significant at the 99% confidence level.

TABLE 3. MEANS, STANDARD DEVIATIONS AND INTERELEMENT CORRELATION COEFFICIENTS FOR THE BEAUCOUP CREEK AREA AND MARYS RIVER AREA

Means

Cd	Co	Cu	Fe	Mn	Ni	Zn
0.2173	7.6972	4.4913	3097	1011	6.390	14.837

Standard deviations

0.1609	5.2808	2.0981	1505	852.3	3.604	13.95

Inter-element correlation coefficients

	Cd	Co	Cu	Fe	Mn	Ni	Zn
Cd	1.0000	0.3088**	0.2599**	0.0939	0.1618**	0.4526**	0.5079**
Co	0.3088**	1.0000	0.1468**	0.3472**	0.5939**	0.6983**	0.1849**
Cu	0.2599**	0.1468**	1.0000	0.3965**	0.0055	0.3393**	0.5519**
Fe	0.0939	0.3472**	0.3965**	1.0000	0.2233**	0.3452**	0.3227**
Mn	0.1618**	0.5939**	0.0055	0.2233**	1.0000	0.5075**	0.0675
Ni	0.4526**	0.6983**	0.3393**	0.3452**	0.5075**	1.0000	0.4165**
Zn	0.5079**	0.1849**	0.5519**	0.3227**	0.0675	0.4165**	1.0000

Number of samples = 374. Critical values of 'r' are: 95% level = 0.103, 99% level = 0.134.

* Significant at the 95% confidence level

** Significant at the 99% confidence level

TABLE 4. RESULTS OF Z-TEST COMPARISONS OF AREAS EAST AND WEST OF THE DuQUOIN MONOCLINE

Element	Z-score
Cd	-4.79*
Co	-5.54*
Cu	-1.12
Fe	-4.96*
Mn	0.26
Ni	-4.59*
Zn	-5.41*

* Statistically significant.

There are several possible hypotheses that can be put forth to explain these differences:

(1) There is a basic difference in the total amount of trace elements in the various basins.

(2) There is a basic difference in the chemistry of trace element release and mobilization between the areas east and west of the DuQuoin Monocline.

(3) There are differences in the amount of area being disturbed by mining in the various basins.

(4) There are differences in the number of samples taken upstream and downstream from mining activity. Because most of the high concentrations of the trace elements occur downstream from mining activity, it follows that an area where mining is in the upper part of the basin might well have a greater total amount of trace elements in the stream sediment. In an area with the mining concentrated at the downstream end of a basin there might be a smaller total amount of high concentration sites.

Possibility number 4 (above) can be dealt with in short order by examining the percentage of sample stations above and below areas of known mining activity. In the Marys River area, located on the far west side of the region, 65 percent of the sample locations can be identified as being above the mining activity. In the Crab Orchard Creek area, this value is 72% and in the Saline River area it is 75%. These numbers are all similar and those east of the monocline have slightly higher percentages of samples upstream from mining; yet these are the areas that have significantly higher contents of the trace elements in the stream sediments.

Possibility number 3 can also be eliminated by a review of Table 1. The percentages of land disturbed by mining in the various counties ranges from 0.71 to 7.17 percent. Saline and Williamson Counties, intermediate in the amounts of disturbed land, contain the greatest numbers of anomalously high samples. On the other hand, Perry County, with the highest percentage of disturbed land, contains only a few such anomalous samples.

Two general possibilities remain. There are either differences in the trace element content of the overburden rocks between the two areas, or there are differences in chemical behavior induced by natural processes or mining activity. Work by Tedesco (1980) did not find any significant differences in trace element content in the various parts of the study area, so possibility number 1 is unlikely. The most probable cause for the differences lies in the stratigraphic differences on either side of the DuQuoin Monocline. East of the monocline, the rocks are predominantly sandstone and shale, with little limestone present to neutralize acids generated by oxidation of pyrite. West of the monocline, limestone is much more common. This tends to neutralize any acids that are generated, usually within the mine site itself. Since the solubility of the metals in general increases with decreasing pH, more metals are able to leave the mine site in those basins with little limestone present (e.g., South Fork). On the other hand, the metals would not be greatly mobilized in a limestone-rich area (e.g., Beaucoup Creek). The following sections will elaborate on some of these points and will discuss in more detail the fate of metals once they are mobilized and enter the stream system.

SECTION 7

METALS IN OVERBURDEN ROCKS

To properly interpret the results of the stream sediment geochemistry, it is desirable to have some knowledge of the trace element geochemistry of the coal mine overburden rocks. Accordingly, two hundred fifty two samples of overburden rocks were collected from 24 mines in southern Illinois. These include all surface mines that were producing over 453,500 metric tons of coal per year and over half of those that were producing less than this amount.

The total amount of the various trace elements found in the individual overburden rocks is not of major concern in this research project, so only a summary of those data is presented here (Table 5). The complete data set can be found in the M.S. thesis by Tedesco (1980). Comparison of the mean values obtained in this study with those of average rocks reported by Wedepohl, et al. (1978) indicates that many of the rocks of southern Illinois coal-producing areas contain slightly higher amounts of most metals (Table 6). In shales, the most common rock in the overburden, arsenic, cadmium, chromium, cobalt, iron, manganese, nickel, and zinc are all higher than the world average. Copper, on the other hand, is almost identical to the average in the shales and is not exceptionally enriched in any of the rock types.

In order to be able to compare the overburden materials to the stream sediment, the overburden rocks were leached with the same hot acid extraction procedure used on the stream sediments. The individual data are given in the M.S. thesis by Tedesco (1980). The results are summarized in Table 7.

Comparison of the trace elements extracted by the hot acid with the total amount present shows that generally small amounts of the trace elements are extractable. The average amounts leached range from 7.1% for chromium to 35.8% for manganese (Table 7). Most elements were leached in the surprisingly narrow range of 9 to 13 percent. These figures are, however, average values for all the samples. Individual values ranged from nearly zero to almost 100 percent for virtually every metal.

TABLE 5. MEANS, STANDARD DEVIATIONS, MINIMUMS AND MAXIMUMS OF TOTAL TRACE ELEMENTS PRESENT (PPM) FOR VARIOUS OVERBURDEN LITHOLOGIES IN THE STUDY AREA

	As	Cd	Cr	Co	Cu	Fe	Mn	Ni	Zn
Soil n* = 30									
Means	60.7	3.73	100.7	28.8	25.3	21757	790.8	50.4	68.2
Std. Dev.	26.1	2.77	37.6	18.0	11.8	5908	678.3	27.3	26.7
Minimum	7.0	0.6	22.0	8.0	4.0	7170	192.0	20.0	23.0
Maximum	91.0	14.0	188.0	94.0	56.0	33800	3240.0	148.0	150.0
Sandstone n = 18									
Means	47.2	3.94	84.9	25.1	20.0	22641	459.2	36.2	69.1
Std. Dev.	29.6	2.21	32.3	11.6	13.6	11048	285.8	16.2	48.7
Minimum	5.0	0.4	10.0	10.0	4.0	2450	42.0	8.0	20.0
Maximum	95.0	8.4	136.0	54.0	48.0	47500	1010.0	68.0	202.0
Limestone n = 41									
Means	26.5	5.44	60.0	18.0	33.4	20510	1090.0	50.2	112.7
Std. Dev.	20.7	6.75	38.6	9.0	25.5	8751	799.8	34.5	249.1
Minimum	2.0	0.8	12.0	6.0	10.0	7680	128.0	6.0	12.0
Maximum	94.0	27.0	186.0	41.0	126.0	43000	3060.0	176.0	1528.0
Shale n = 108									
Means	56.3	9.07	222.8	32.6	41.9	28948	714.8	103.4	222.1
Std. Dev.	28.0	10.86	257.5	24.5	22.4	11125	749.1	82.1	368.0
Minimum	9.0	0.6	14.0	4.0	6.0	223	54.0	14.0	18.0
Maximum	103.0	70.0	1320.0	234.0	166.0	69400	3880.0	386.0	2280.0
Coal n = 33									
Means	46.3	12.5	64.5	23.8	19.3	23586	300.0	50.0	107.2
Std. Dev.	30.9	17.9	63.8	13.1	16.3	12127	337.0	30.7	107.1
Minimum	5.0	1.00	6.0	6.0	6.0	9600	22.0	14.0	18.0
Maximum	96.0	74.0	366.0	78.0	78.0	62400	1436.0	190.0	456.0
Underclay n = 21									
Means	28.1	5.62	108.9	33.0	42.3	21954	710.7	68.8	73.4
Std. Dev.	20.3	2.80	45.1	13.0	31.3	10909	1016.0	30.9	60.9
Minimum	2.0	1.2	10.0	12.0	4.0	6990	74.0	34.0	18.0
Maximum	58.0	11.0	158.0	56.0	156.0	47400	3740.0	134.0	280.0

* Number of samples analyzed.

TABLE 6. TRACE METAL CONCENTRATIONS IN COAL AND OVERBURDEN MATERIALS

	As*	Cd*	Cr*	Co*	Cu*	Fe**	Mn*	Ni*	Zn*
Literature									
Limestone (avg)[1]	1.0	----	----	1.9	6.6	0.35	386.0	71.0	70.0
Sandstone (avg)[1]	1.0	----	39.0	11.0	18.4	1.05	542.0	32.0	58.0
Shale (avg)[1]	13.0	1.40	165.0	19.0	42.0	1.75	535.0	4.5	163.8
Coal (avg)[1]	----	----	----	3.5	19.0	----	----	----	----
Coal (avg)[2]	14.0	2.20	18.0	7.3	14.0	2.00	53.0	21.0	250.0
Soil (avg)[3]	----	----	200.0	12.5	27.5	----	500.0	99.0	475.0
This study									
Limestone (avg)	26.5	5.44	60.0	18.0	33.4	2.05	1090.0	50.2	112.7
Sandstone (avg)	47.2	3.84	84.9	25.1	20.9	2.26	459.2	36.2	69.1
Shale (avg)	56.3	9.07	222.8	32.6	41.9	2.90	714.8	103.4	222.1
Coal (avg)	46.3	12.50	64.5	23.8	18.3	2.36	300.0	50.0	107.2
Soil (avg)	60.7	3.73	100.7	28.8	25.3	2.18	790.8	50.4	68.2

1 - Wedepohl (1978); 2 - Gluskoter et. al. (1977); 3 - Aubert and Pinta (1977).
* Parts per million
** Percent of rock

TABLE 7. TOTAL TRACE ELEMENTS PRESENT AND AMOUNTS OF TRACE ELEMENTS WHICH ARE HOT ACID LEACHABLE: SOUTHERN ILLINOIS COAL MINE OVERBURDEN ROCKS

Element	Amount of Trace Element Present (ppm)	Percentage Leachable
As	2.96	11.1
Cd	0.431	9.0
Cr	5.32	7.1
Co	3.87	16.4
Cu	5.54	18.9
Fe	1235.0	9.0
Mn	205.6	35.8
Ni	8.58	12.5
Zn	12.01	8.4

A comparison of hot acid leachable trace element means from the regional stream sediments and the hot acid leachable trace element means from the overburden rocks suggests that, in general, there are greater amounts of leachable elements in the stream sediments (Table 8). Iron and manganese are more leachable from stream sediments than from overburden lithologies by a minimum factor of two. Iron is commonly present in the streams draining from surface mines as a precipitate called yellowboy. Manganese is probably deposited as oxide coatings onto the stream sediments (Jenne, 1968). Cobalt and zinc are higher in stream sediment than in any lithology of fresh rock, possibly by virtue of being adsorbed onto clays or oxide coatings in the stream. On the other hand, cadmium is more abundant in unweathered shale and limestone than in stream sediment, copper is higher in shale and soil, and nickel is higher in shale and underclay than in stream sediment.

In humid climates, rocks are generally subjected to chemical weathering processes that leach the more soluble elements from the bedrock and transport them elsewhere. Surface mining disrupts this normal course of events by bringing large quantities of unweathered material to the surface and making it available for erosion into nearby streams. If such unweathered material contains higher concentrations of metals than the stream sediment, any anomalous values below mines might simply represent the physical influx of unweathered sediment into a stream rather than geochemical processes removing metals from water and accumulating them in sediment. The generally higher values of the metals in the stream sediment, especially in the areas downstream from mines where concentration of several times the median values of the overburden rocks are commonplace, suggests that this is not the case and that geochemical processes are responsible for metal accumulation downstream from mining activity. The nature of these processes can be better understood by examining the behavior of metals in individual streams draining mined areas. This will be examined in the next section.

TABLE 8. MEANS AND STANDARD DEVIATIONS FOR AMOUNTS (PPM) OF HOT ACID LEACHABLE TRACE ELEMENTS IN VARIOUS OVERBURDEN LITHOLOGIES AND STREAM SEDIMENTS

	Cd	Co	Cu	Fe	Mn	Ni	Zn
Soil							
Means	0.302	3.77	4.61	833.2	247.6	4.76	5.64
Std. Dev.	0.528	2.44	2.81	997.8	221.7	2.96	2.94
Sandstone							
Means	0.137	3.39	3.39	1854.0	288.3	4.63	8.29
Std. Dev.	0.086	3.02	3.02	1664.0	259.0	2.48	9.16
Limestone							
Means	0.401	2.78	3.35	886.6	233.0	7.33	9.78
Std. Dev.	0.490	2.25	5.60	1846.0	266.7	11.65	22.5
Shale							
Means	0.657	4.78	7.69	1545.0	209.5	11.68	16.81
Std. Dev.	1.282	2.98	8.13	1524.0	273.4	9.69	27.07
Coal							
Means	0.150	2.61	4.38	971.9	164.4	5.41	11.68
Std. Dev.	0.089	2.51	6.05	648.3	293.3	5.12	21.38
Underclay							
Means	0.204	4.06	3.75	778.6	225.4	8.93	4.45
Std. Dev.	0.167	4.23	3.72	829.2	357.3	9.89	4.43
Stream Sediments							
Means	0.32	10.1	4.43	3790.0	837.0	8.3	20.4
Std. Dev.	0.57	7.0	3.96	2707.0	937.0	8.1	24.0

SECTION 8

DETAILED STREAM STUDY

INTRODUCTION

To examine the seasonal fluctuations of the elements under study and to better understand their movement downstream from a source, three small streams located in Saline and Williamson Counties were selected for detailed study of water and sediment. The sampling programs for these areas are designated the H-series, S-series and C-series, respectively (Figure 36). The H-series is superior to the other two inasmuch as there is a very localized area influenced by mining activities and the stream can be followed for several kilometers without the complications of major tributaries. Consequentially, this stream is singled out for extensive evaluation; the other two are used mainly for comparison. Raw data from this portion of the study can be found in Appendices B and C.

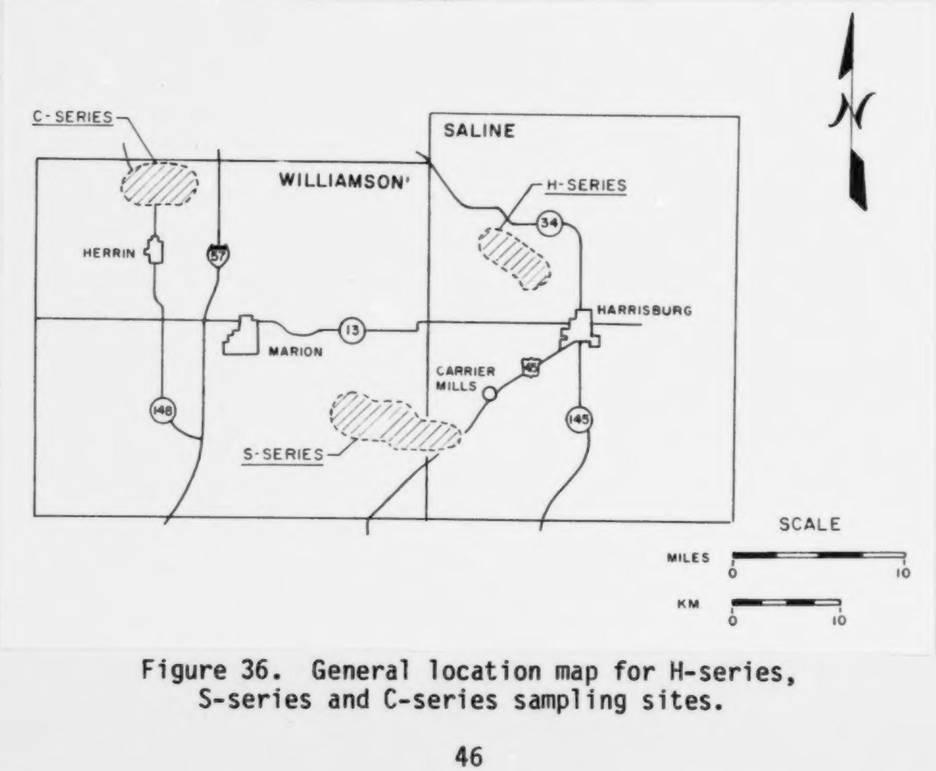

C-SERIES
SALINE
WILLIAMSON
H-SERIES
N
HERRIN
57
34
HARRISBURG
13
MARION
CARRIER MILLS
45
148
145
S-SERIES
SCALE
MILES
0
10
KM
0
10

Figure 36. General location map for H-series, S-series and C-series sampling sites.

H-SERIES

The H-series of samples is located on an unnamed stream, hereafter called Harco Branch, located about 13 kilometers northwest of Harrisburg in Saline County, Illinois (Figure 37). Harco Branch begins in the immediate vicinity of coarse refuse piles of the old Peabody 47 underground coal mine. This drainage was monitored by nine sample locations, spaced from 0.4 kilometer to 1.6 kilometers apart, which cover a stream length of approximately 7 kilometers. Seven of the collection sites are along Harco Branch upstream from its confluence with Brushy Creek. Sample site H-6 is in Brushy Creek just upstream from the point where Harco Branch joins it, and site H-8 is in Brushy Creek, less than a half kilometer downstream from the confluence of Harco Branch. This sample series offers the best area for following the progress of trace elements downstream, because they enter the stream in a very localized area (the refuse piles) and travel downstream without appreciable outside influence until Harco Branch joins Brushy Creek.

Seasonal Variation of Trace Elements in Water

Waters from all the sample sites on Harco Branch show a pronounced seasonal concentration variation for every trace element examined. A good example to illustrate the seasonal differences is site H-4, located approximately 2.1 kilometers downstream from the refuse of Harco Mine. This site shows an increase in concentration during the summer and fall months (Figure 38). A few very high values are omitted from the figure in order to accentuate the others. The upward trend begins in late May and early June, and the concentrations decrease again in late November and early December. Ninety percent of the values exceeding twice the median concentration occur from June through October. A similar marked increase in aqueous iron concentrations was found in the South Fork of the Saline River in Saline County, Illinois (Rosso, 1975).

After the elements have reached the higher summer concentration, only minor fluctuations occur. Site H-4 shows this general trend for all elements except iron, which hits a single definitive peak in August (Figure 38f). The other elements have a strong similarity in their general trend and in their minor fluctuations as well.

The seasonal trend shown at this particular site is also representative of other sites along Harco Branch. Site H-6, located in Brushy Creek, is not influenced by mining, has much lower concentrations of the elements in water throughout the year, and never shows a strong seasonal trend. Therefore, Brushy Creek will not further be considered when seasonal trends are discussed.

There are several possible reasons for the seasonal behavior of the elements at this site. Chemical reaction rates are known to increase with an increase in temperature, thereby resulting in increased oxidation of pyrite during summer. The results of oxidation are twofold: first, it adds more iron to the system, and more importantly, adds sulfuric acid. The acid aids in solubility and mobility of the trace elements so that higher concentrations are present in summer.

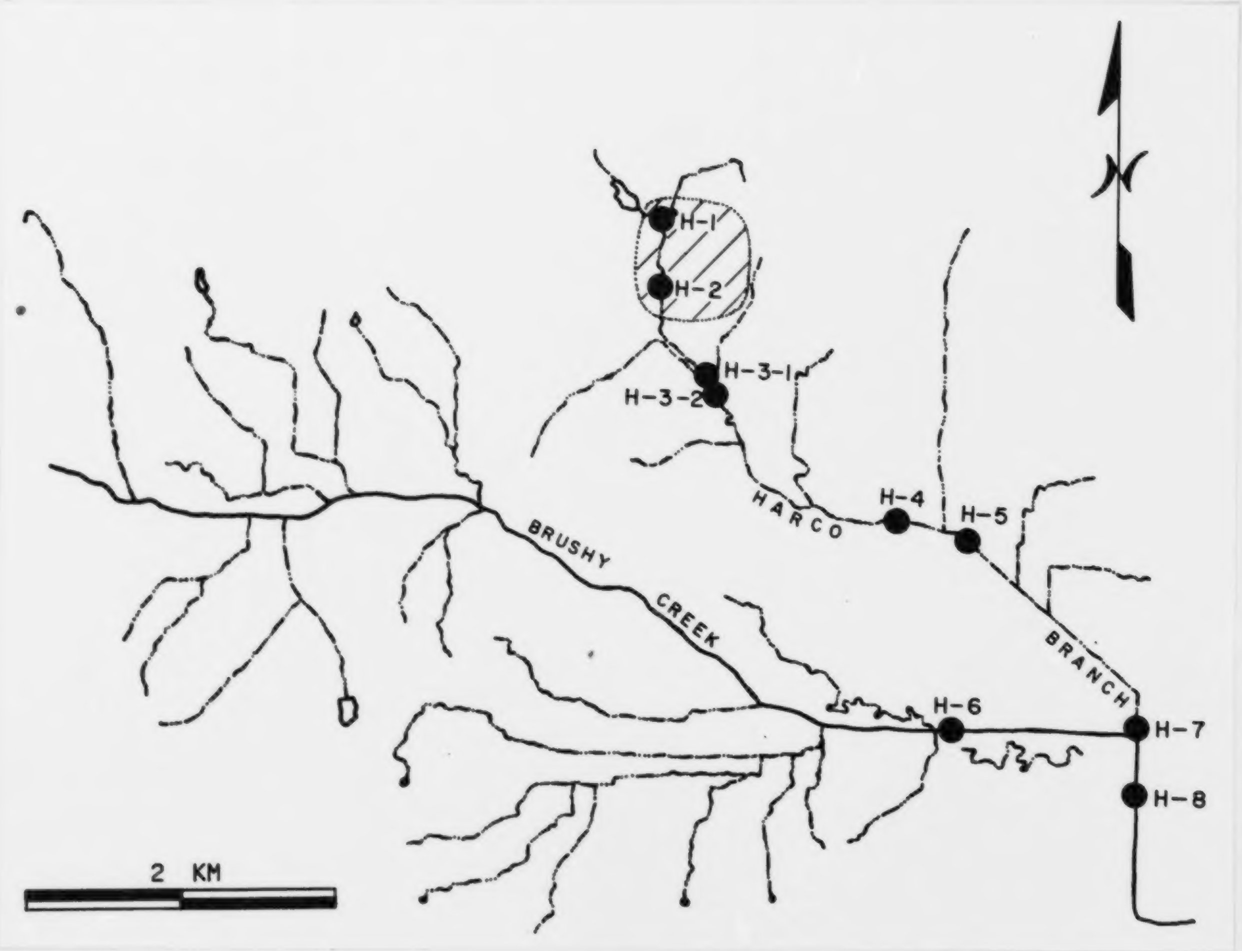

N
H-1
H-2
H-3-1
H-3-2
H-4
H-5
H-6
H-7
H-8
HARCO
BRANCH
BRUSHY
CREEK
2 KM

Figure 37. Map of H-series.

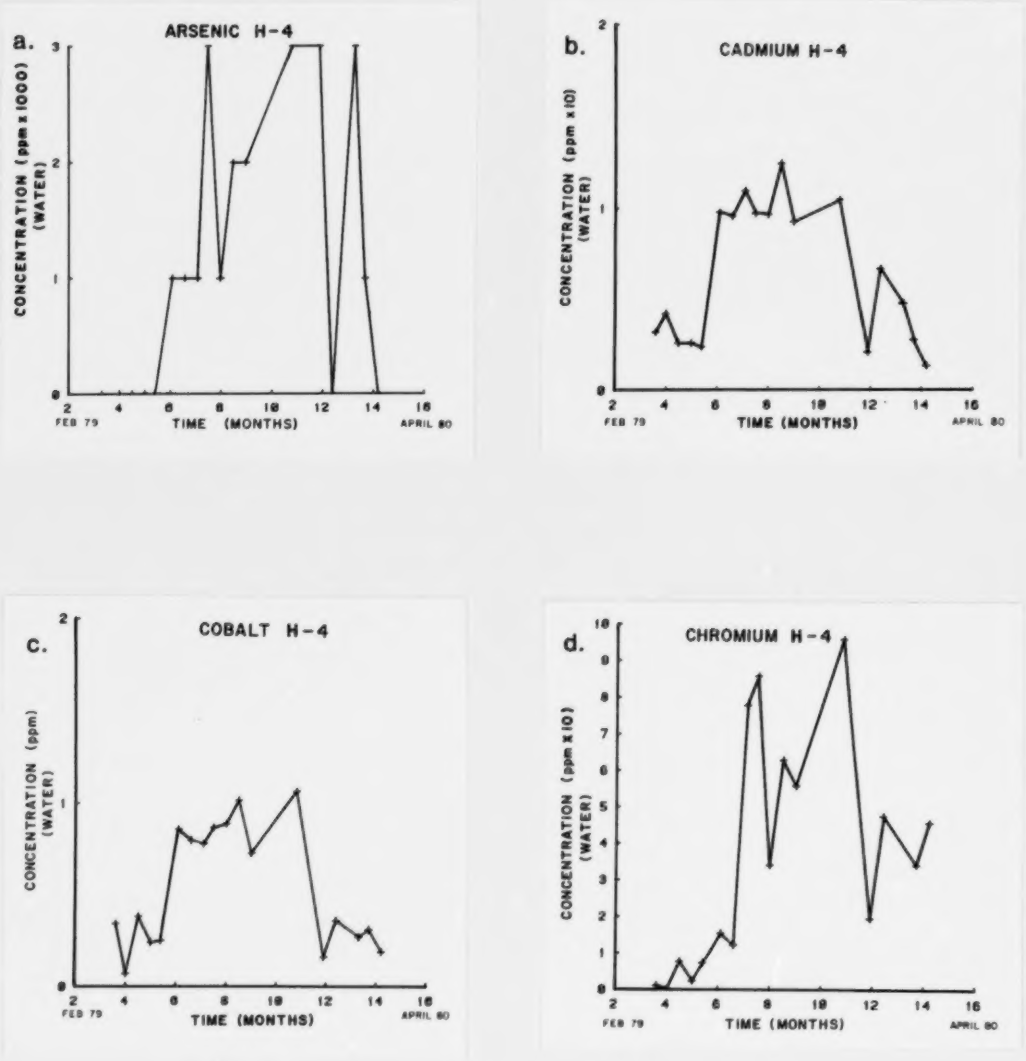


Figure 38. Trace element concentrations in water vs. time: site H-4.

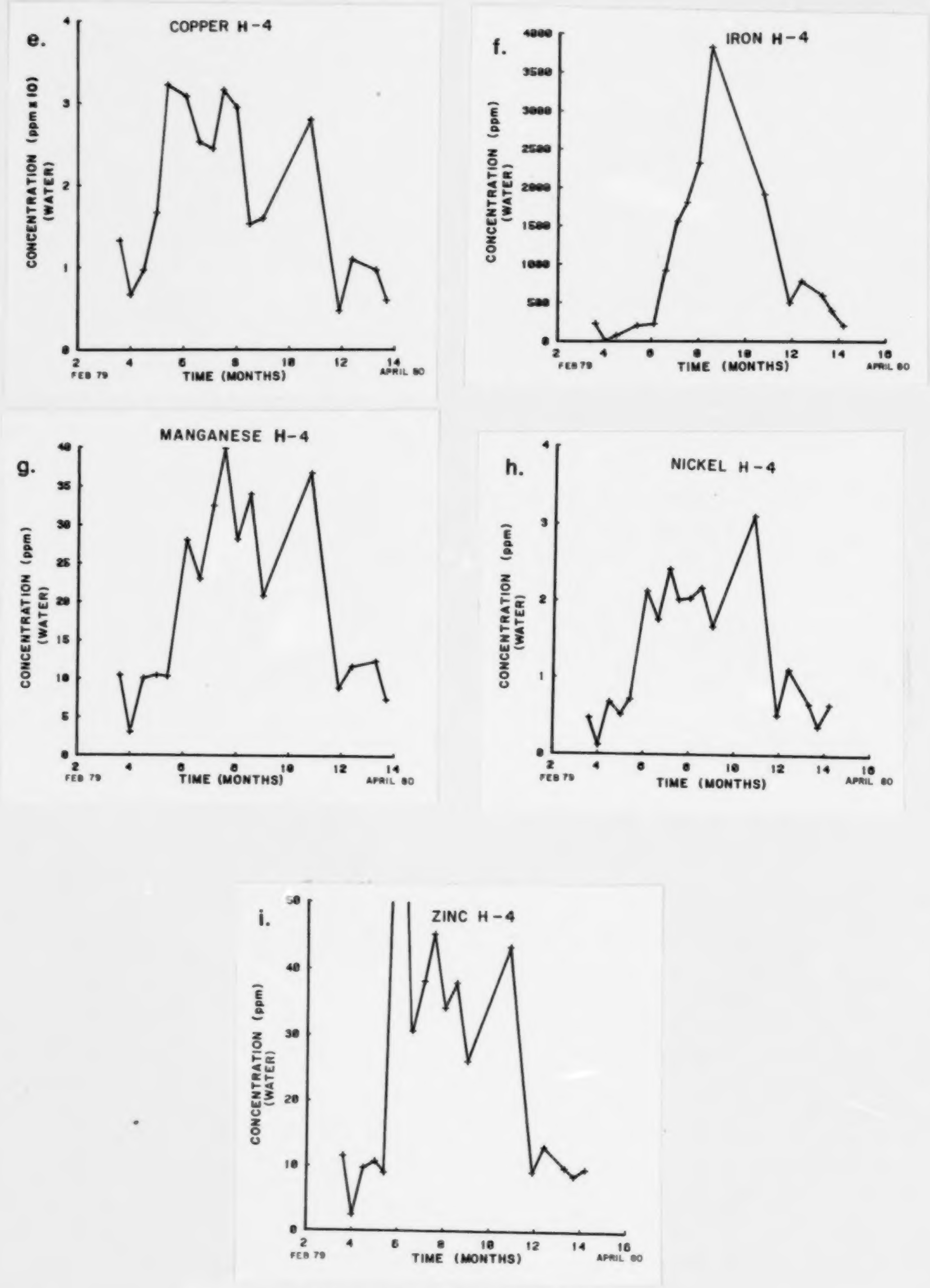


Figure 38 (continued)

Increased biological activity is another likely cause for the observed seasonal trend. There are a few species of bacteria which are acidophilic and utilize the energy produced by the oxidation of iron and sulfur compounds. Pyrite contains reduced forms of both iron and sulfur, which are utilized by the bacteria (Dugan, 1972). The bacteria thrive in water with pH below 4 (Clark, 1965). The lower pH caused by increased chemical oxidation during summer promotes oxidation by bacteria, which, in turn, increases the formation of sulfuric acid. The acid then dissolves trace elements from the rocks. In summary, due to higher temperatures in the summer months, bacterial and chemical activity are synergistic.

The high concentration of trace elements in summer months is not due to low rainfall because rainfall was higher at the same time that the concentrations of the elements increased. As an example, Figure 39 shows the concentration of the element manganese, superimposed on the rainfall histogram. There was a relatively large amount of precipitation in spring and winter, which was associated with lower concentrations of manganese. However, in the summer when there was an increase in precipitation, the manganese concentration remained high. Thus, it appears that the rainfall does not dilute the high concentration of trace elements in the summer, nor is the high concentration a result of low rainfall.

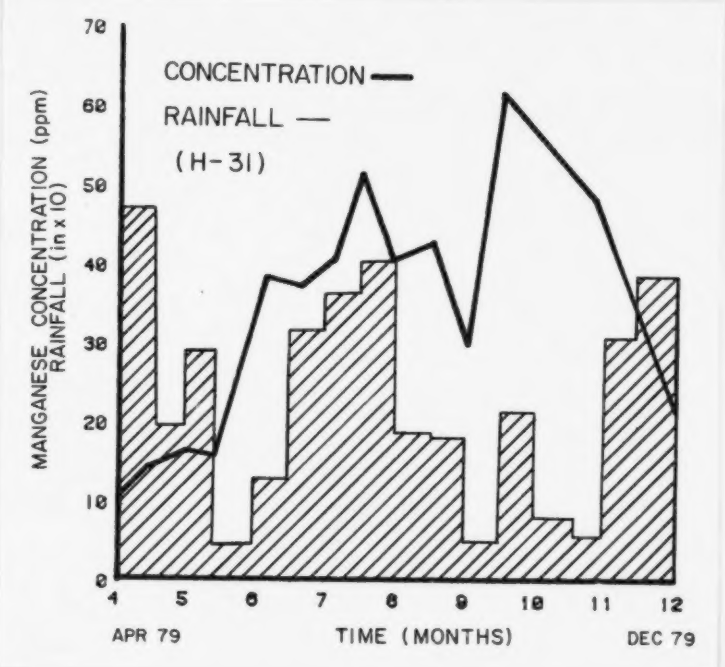


Figure 39. Concentration of manganese in water vs. amount of rainfall, April through December.

Although rainfall does not affect the major seasonal trend, it may cause minor fluctuation by affecting local runoff and discharge. For example, in the spring months of April and May, when there is a two-week period of high rainfall in early April, there is a corresponding low concentration of manganese. In the second half of April, there is a decrease in rainfall and manganese concentration starts to rise again. In early May, there is increased rainfall with a subsequent slight drop in manganese concentration. There is a dramatic jump in concentration at the end of May which corresponds to a dry period. Thus, the precipitation does affect the concentration to some extent until the major summer increase appears.

Fluctuation may also be a result of precipitation of the various elements, although this mechanism is not considered to be a major influence. Each of the elements under study has a different solubility (Krauskopf, 1979), yet they follow nearly identical concentration trends. If their concentration trends were dramatically different, precipitation would be more likely as a major influence. If precipitation is occurring, it is difficult to visualize how all the elements could rise and fall so systematically, especially since they are so much below saturation (Stumm and Morgan, 1970, p. 181).

Seasonal Variation of Trace Elements in Sediment

The seasonal differences in concentration of trace elements which are found in sediment samples are much less pronounced than the variations found in water samples. For example, at site H-4, which shows strong seasonal variation in water, the trace element concentrations in sediment do not show an appreciable seasonal upward summer trend (Figure 40). Ninety percent of the abnormally high values which are present in water samples occurred in a five month period from June through October. In sediment, only 60% of the high values occurred in the same period of time, and there is greater fluctuation throughout the year.

Erratic values may be due to changes in the ratio of older stream sediment to that recently reaching the collection site, either by transport from far upstream or by washing in from the banks. Newer sediment would have had less time to adjust to conditions at the sampling site and thus might change the concentration of a given trace element upwards or downwards, depending upon conditions.

Concentration of Trace Elements in Water vs. Distance Downstream From the Source

In order to examine the behavior of the elements as they are transported downstream from the source, plots were made of the concentrations of the trace elements in water as a function of distance from the source (zinc, manganese, and iron). Zinc is illustrated because its behavior in water is typical of most of the other elements in this study. Manganese and iron are also chosen because, unlike zinc, they frequently precipitate out of streams to form oxyhydroxide coatings on stream sediments. Data from April, July, October and January are used to show the seasonal trends.

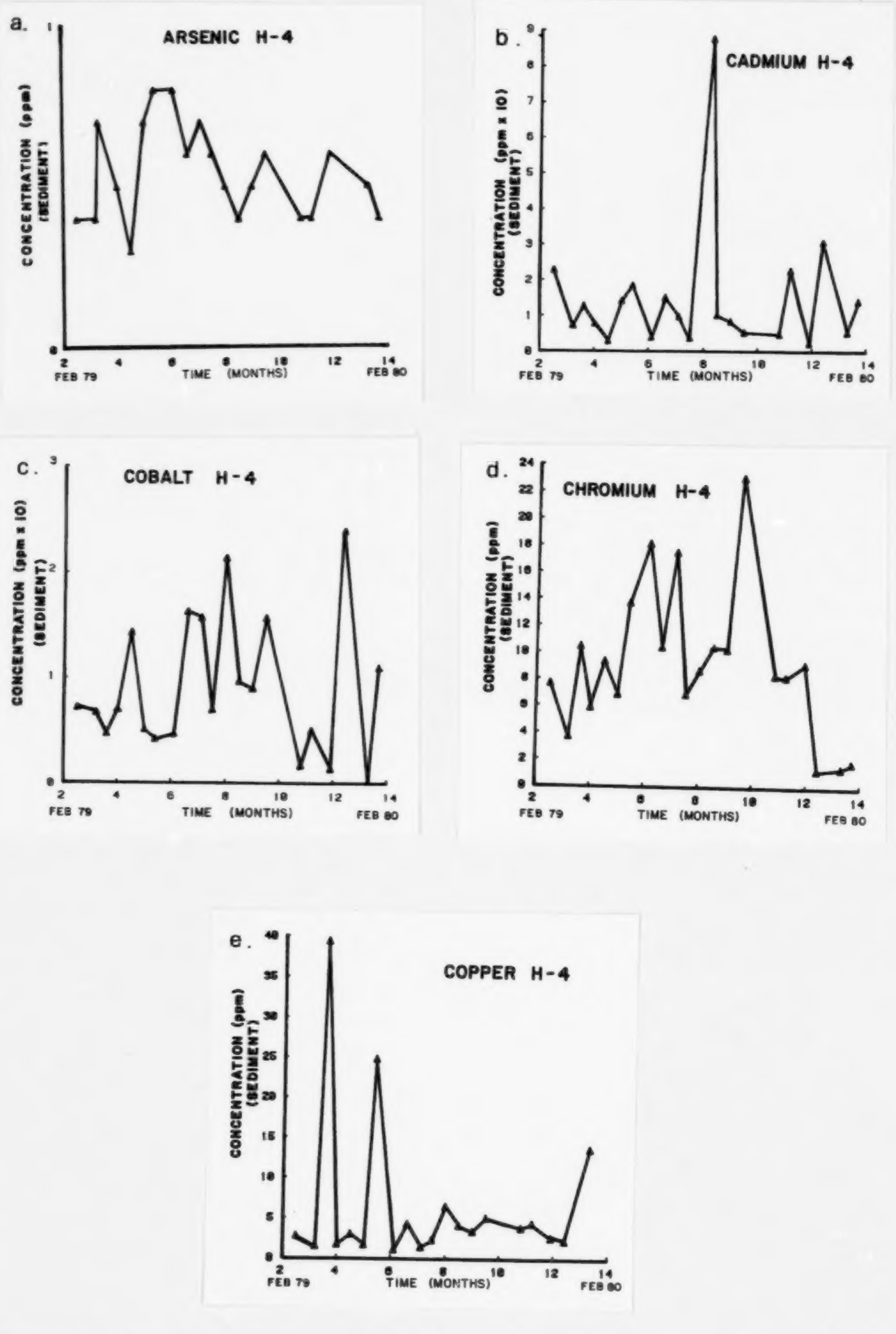


Figure 40. Trace element concentrations in sediment vs. time: site H-4.

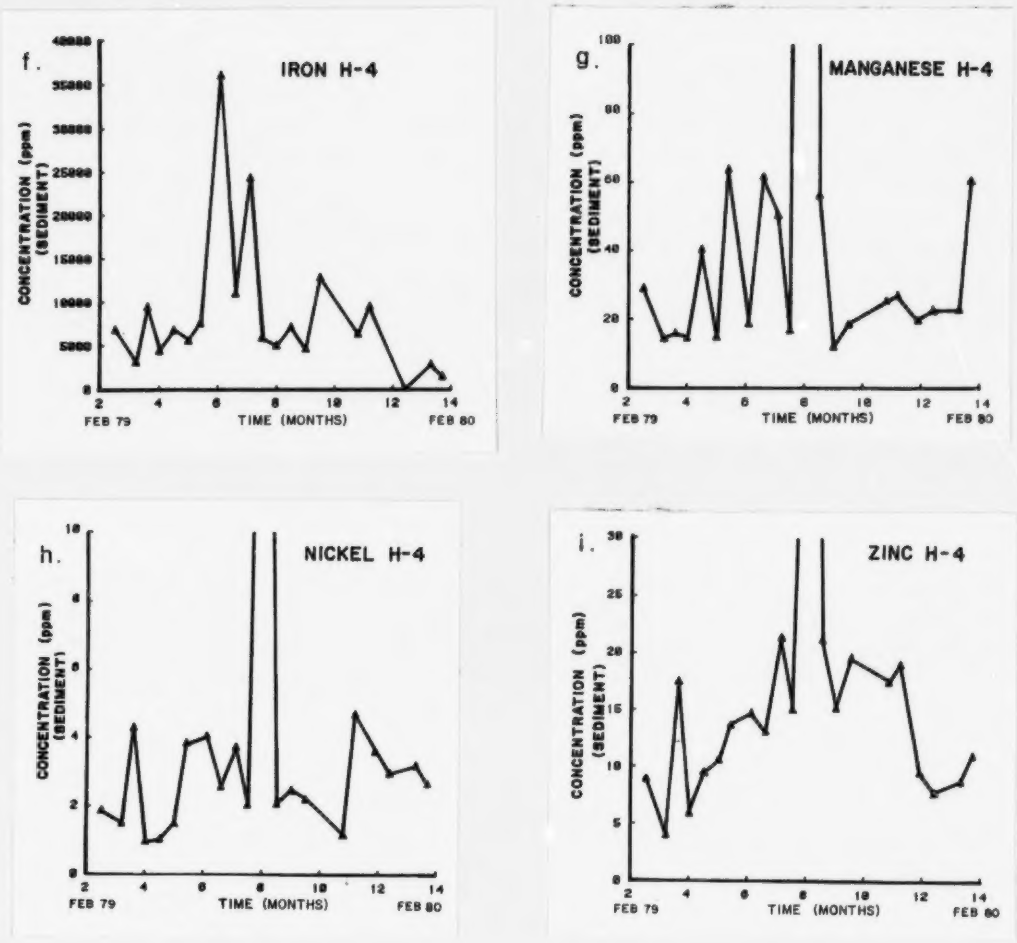


Figure 40 (continued)

All of the elements show similar trends, i.e., concentrations become lower downstream (Figures 41, 42, 43). The highest values are always at either H-2 or H-31, and the next site downstream, H-32, is always much lower; from there on the downstream decreases are more gradual, although another rapid decrease does occur between the last two sites. This is attributable to the influence of Brushy Creek, which joins with Harco Branch between these two points. The observed decrease in concentration may be caused by dilution by surface water or by removal from solution. The relative merits of each mode of decrease will be discussed in the stream sediment section.

Superimposed upon the overall decreasing downstream trend is a seasonal variation in concentration. Zinc values range from 0.00 to 22.00 ppm in April and January (Figures 41a and d), and from 0.00 to 70.00 ppm in July and October (Figures 41b and c). Comparable changes also occur in iron and manganese values (Figures 42 and 43, b and c). In winter and spring, occasional small reversals in the overall decreasing trend are observed. In general, manganese, iron, and zinc all show the same trend in spite of differences in geochemistry.

Downstream Changes in Trace Elements in Sediment

If the yearly mean concentrations of trace elements in sediment are plotted as a function of distance from source, a behavior different from the trends found in water can be seen (Figure 44). In water, virtually every one of the nine elements decreased in concentration downstream. The concentrations of trace elements in sediment also generally decrease downstream, but give a peak value about three kilometers downstream from the source.

Five elements (cadmium, cobalt, copper, manganese and nickel) tend to show a decrease in concentration in sediment at the first three upstream sites in Harco Branch. These elements also had corresponding decreases in water. This suggests either a dilution of both sediment and water or precipitation of trace elements without accumulation in the sediment. The precipitation explanation is the more likely. Peak values for these five elements in the sediment occur downstream at either site H-4 or H-5, suggesting that they are beginning to precipitate in the upper reaches of the stream but do not settle to the stream bottom until later. Further downstream from the area of maximum concentration the values tend to decline, until at the junction with Brushy Creek there is an influx of sediment which contains greater amounts of the trace elements than were present in Harco Branch at H-7. This influx generally results in a final increase in concentration of trace elements in the sediment between the last two sites of the H-series.

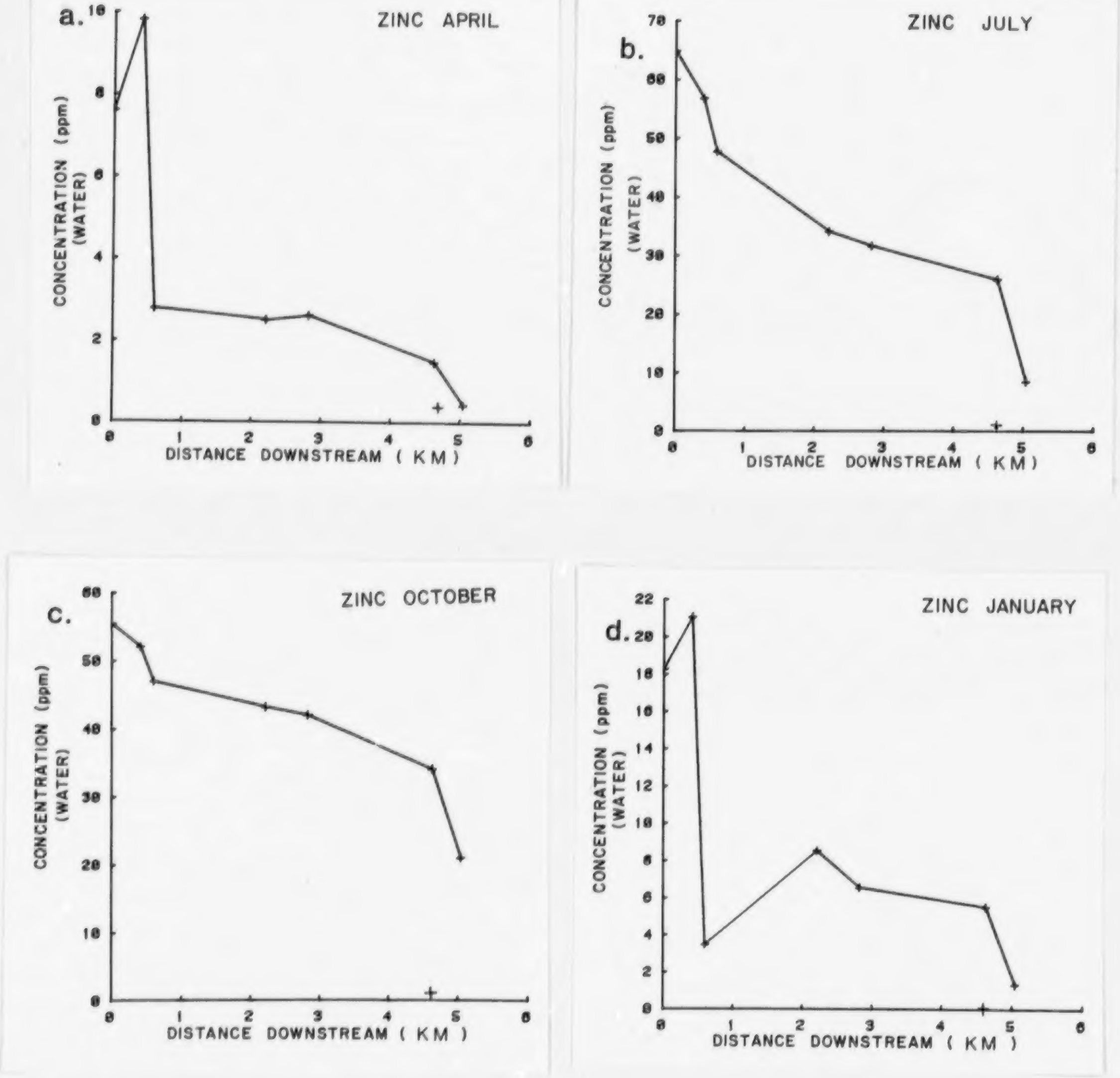


Figure 41. Concentration of zinc in water during various seasons vs. distance downstream.

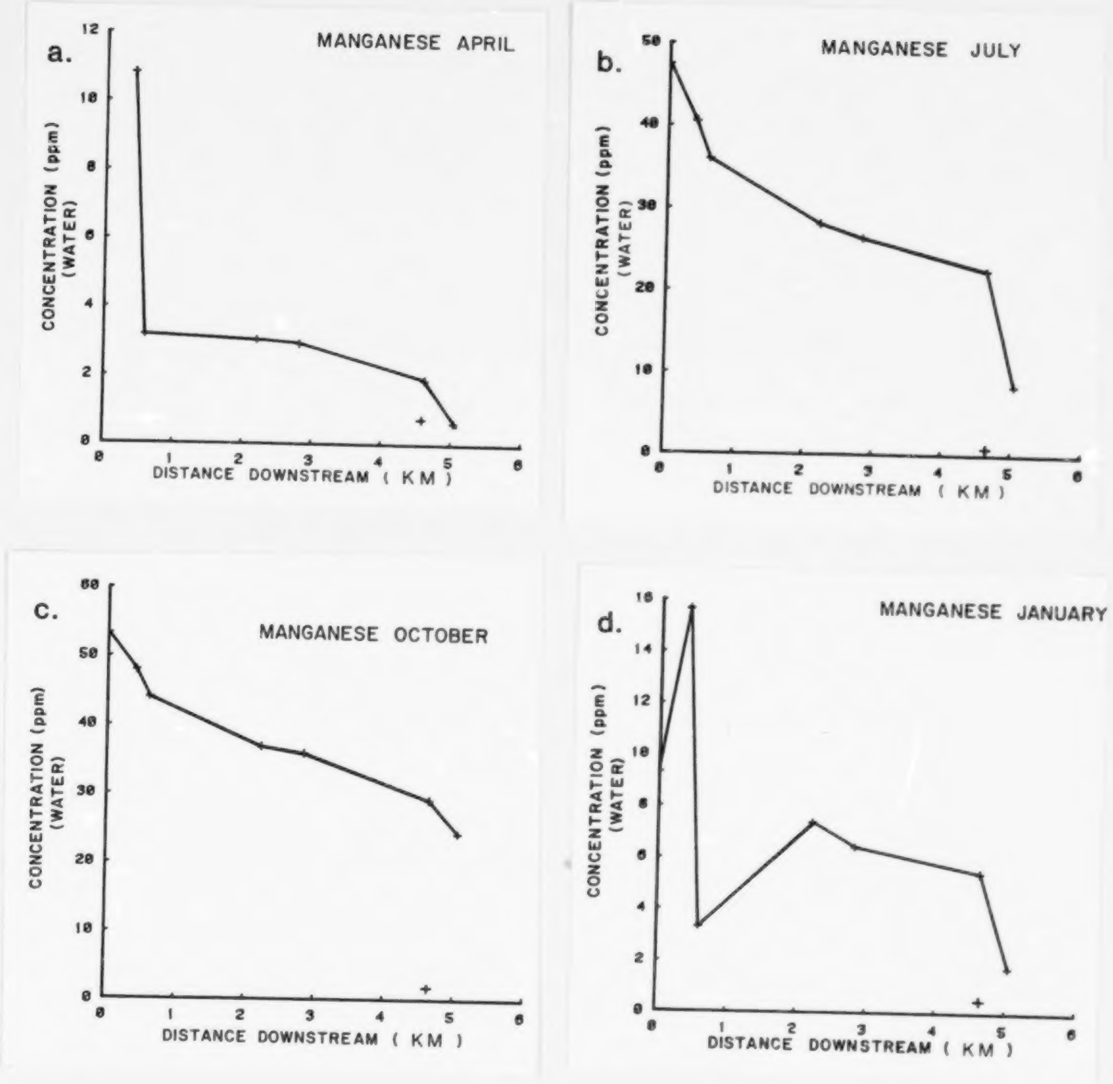


Figure 42. Concentration of manganese in water during various seasons vs. distance downstream.

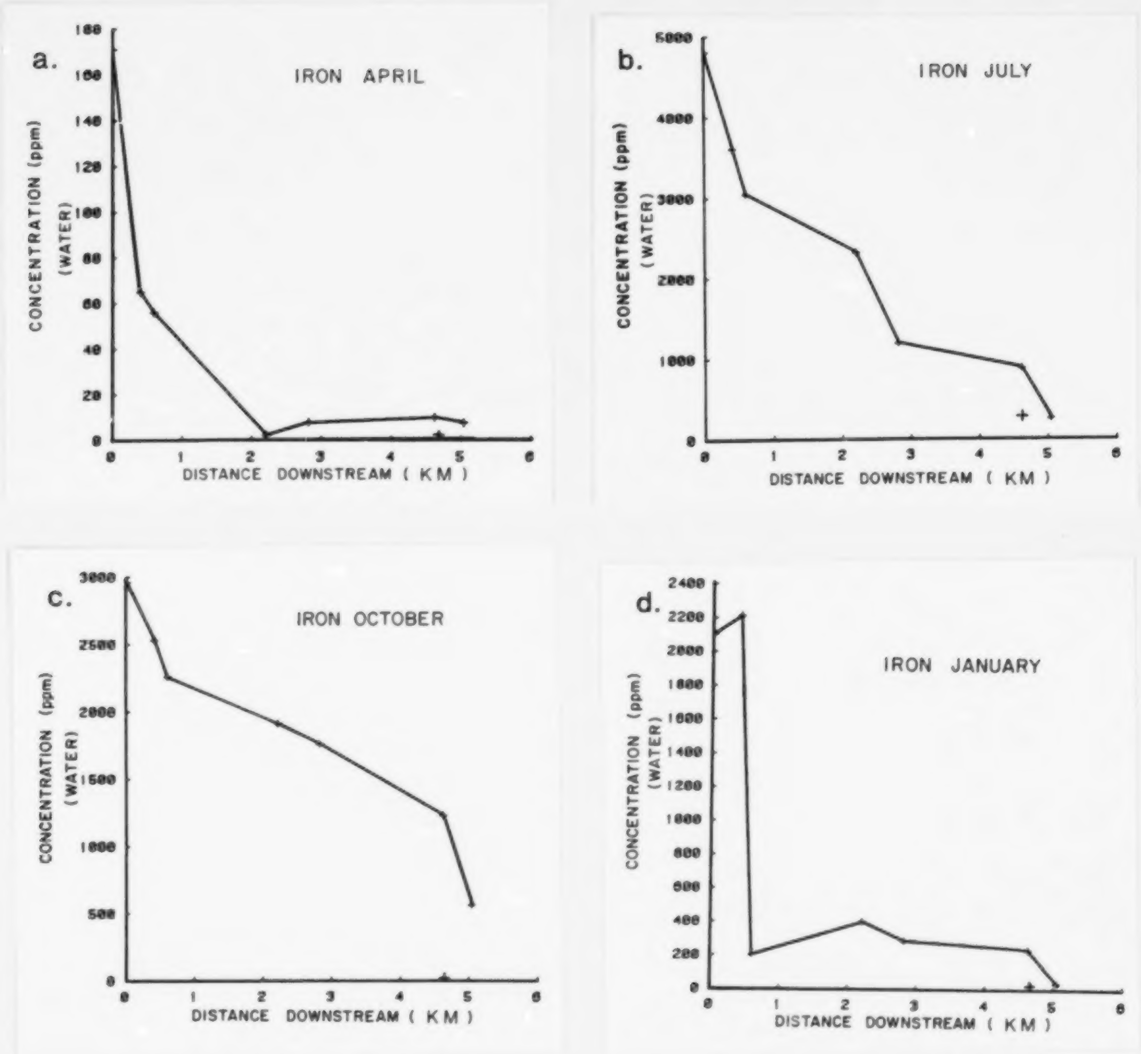


Figure 43. Concentration of iron in water during various seasons vs. distance downstream.

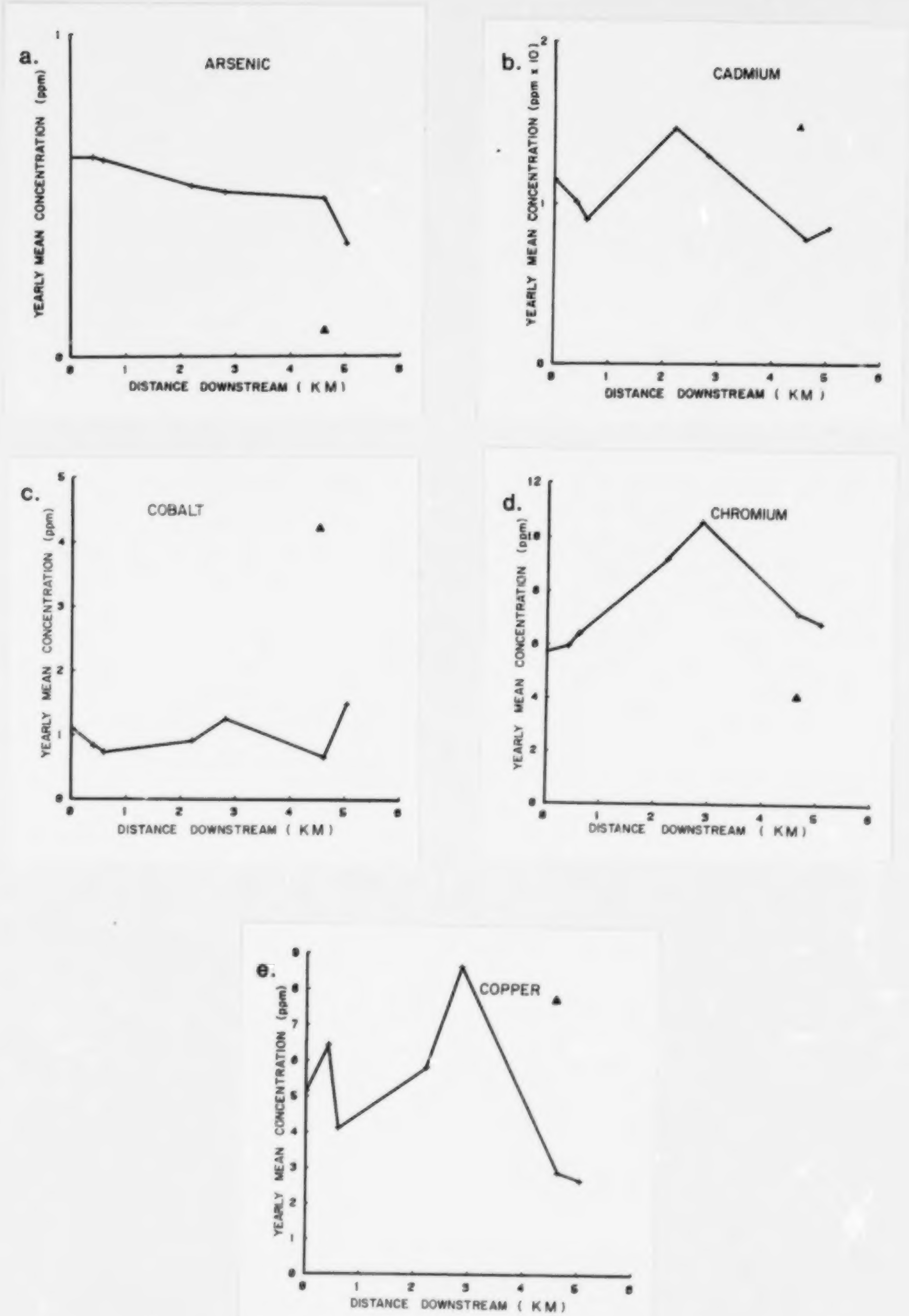


Figure 44. Mean trace element concentration in sediment vs. distance downstream.

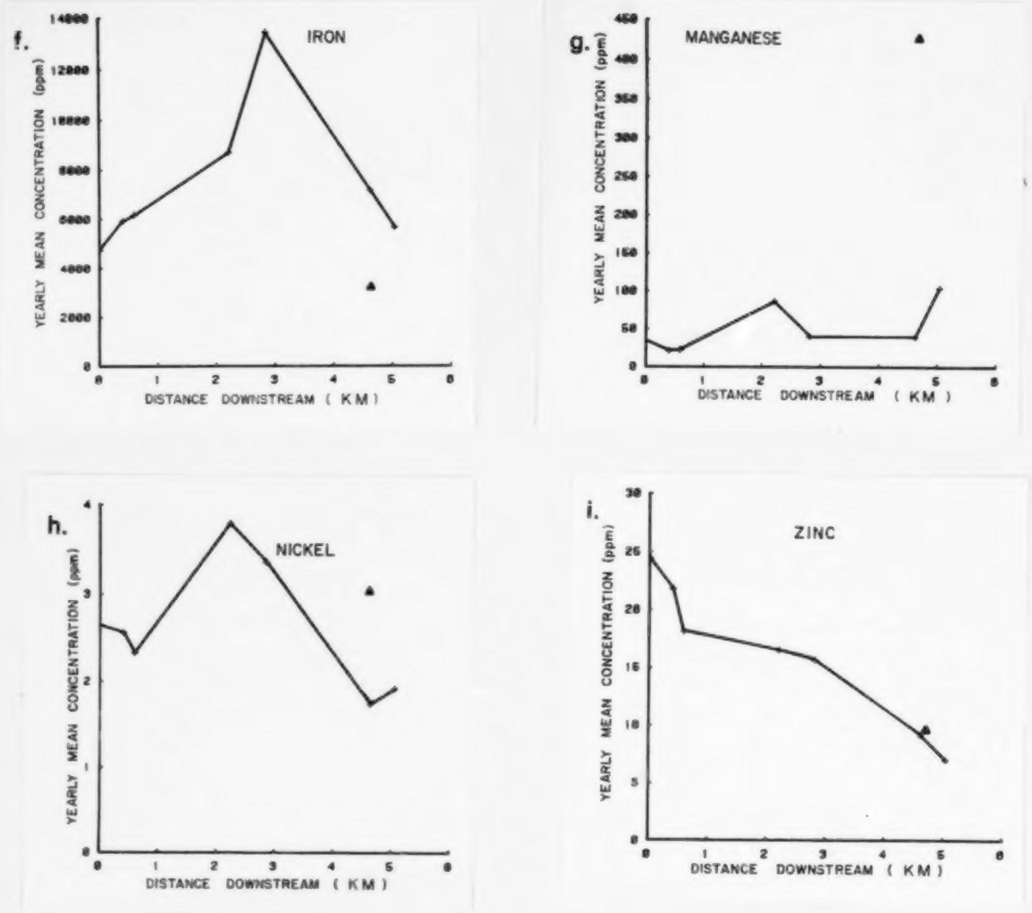


Figure 44 (continued)

Two elements, chromium and iron, increase downstream through the first five sampling sites, then decrease for the rest of the distance. The corresponding decrease of these elements in water indicates that they are precipitating out of solution beginning very close to the source of contamination. After the bulk of the precipitate has accumulated in the sediment, there is a decrease caused by dilution of sediment and water downstream. Further downstream, at the confluence of Harco Branch and Brushy Creek, Brushy Creek carries lower amounts of these two elements, in contrast to the more common situation in which it has higher concentrations. Thus, after mixing, there are smaller amounts of iron and chromium in the sediment than were brought down by Harco Branch.

The only two elements which consistently decrease without peaking in value downstream are zinc and arsenic. These elements also show a downstream decrease in concentration in water. A plausible explanation for the decrease of zinc and arsenic in water could either be by dilution or by precipitation. However, the mean values for these elements in the sediment do not increase, which seems to argue against precipitation, although precipitation might be masked by the influx of materials containing little zinc or arsenic, or the precipitate might remain in suspension and be carried along downstream. It seems just as likely that these two elements are not precipitating along the length of Harco Branch but are simply being diluted by the influx of other materials.

Concentration of Trace Elements in Water as Affected by pH

The pH of the environment is an important aspect of the geochemistry as it relates to the behavior and concentration of the trace elements. To illustrate this, the mid or late August concentration values are plotted vs. corresponding water pH from each site. All three stream basins are used to give a wider range in pH. Concentrations of the trace elements in water are greater at low pH, and very low in normal pH waters of 6 to 8 (Figure 45). Many of the concentrations in high pH ranges are extremely low, and cluster at almost negligible concentrations.

In the H-series, most of the sites are high concentration/ low pH; however site H-6, located in Brushy Creek, always has a high pH and lower concentrations of trace elements in water throughout the year and site H-8, which occurs after the mixing of Brushy Creek and Harco Branch waters, is low concentration/low pH. The important feature to note at site H-8 is that although it has markedly lower elemental concentrations than the other Harco Branch sites due to dilution by Brushy Creek, it has retained the low pH of Harco Branch. Thus, the concentrations of trace elements in these stream waters seem to usually be pH dependent, as low concentrations are found in high pH waters and vice versa. The only difference in behavior may occur when there is mixing of the two types of water, i.e. high pH/low concentration or low pH/low concentration.

Concentration of Trace Elements in Sediment as Affected by pH

When values for trace elements in sediment collected during the mid- to late August sampling period are plotted as a function of pH, an interesting pattern is discernable (Figure 46). In contrast to elemental concentration in water, the sites at which water has high pH have high concentrations of most trace elements in the sediment. The opposite is also true, i.e., the sites with low pH tend to have low concentrations in the sediments. This behavior is exhibited by cadmium, cobalt, manganese, nickel and zinc (Figures 46b, c, g, h and i). Copper is the only element that does not show appreciable variation with pH. (Figure 46e).

The pattern exhibited by arsenic, chromium, and iron (Figures 46a, d, and f) is different in that these elements are not clustered according to low pH/low concentration; rather, their concentrations cover a much wider range. This may be due to the precipitation of the iron through a wide range of pH values when compared to the precipitation of other elements. Chromium can coprecipitate with the iron. The extremely low concentrations of arsenic make interpretations risky.

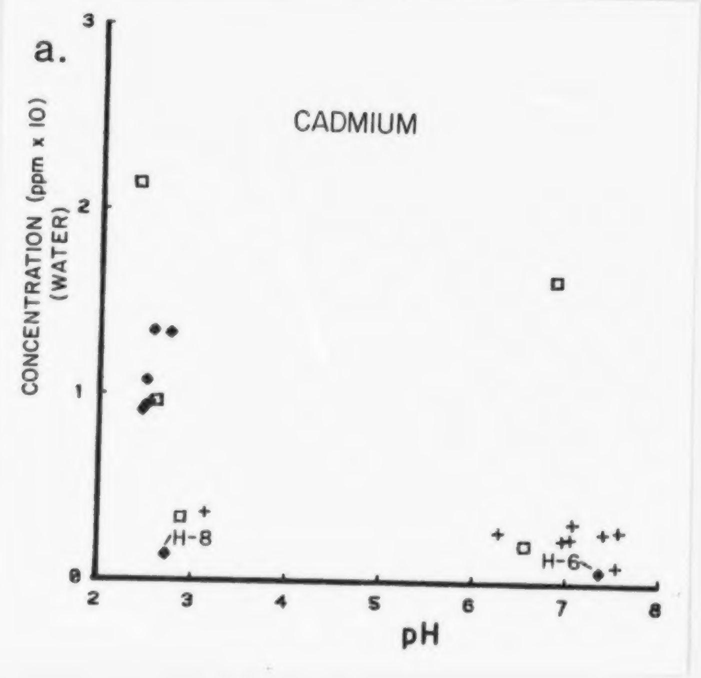
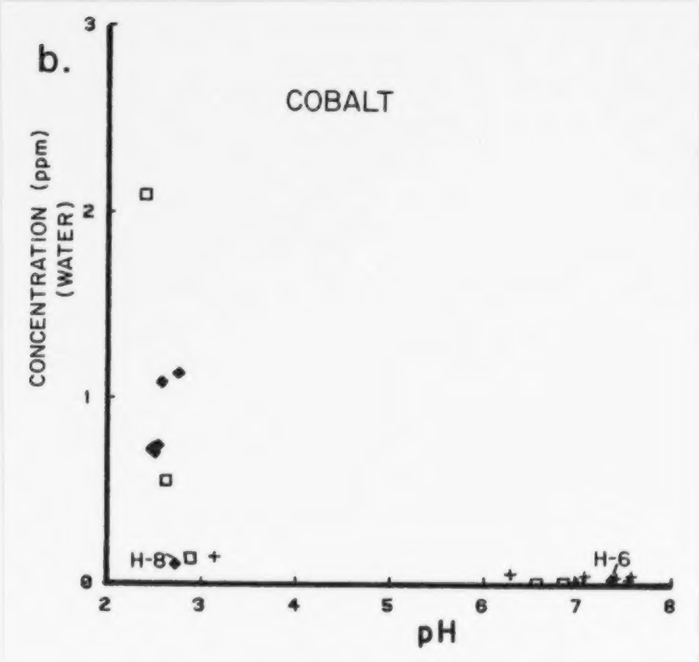
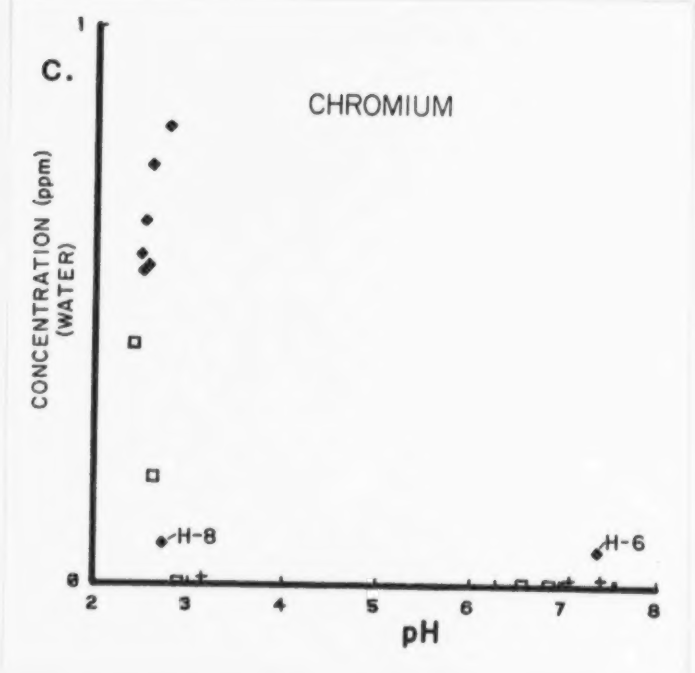


Figure 45. Trace element concentrations in water vs. pH, all sites.





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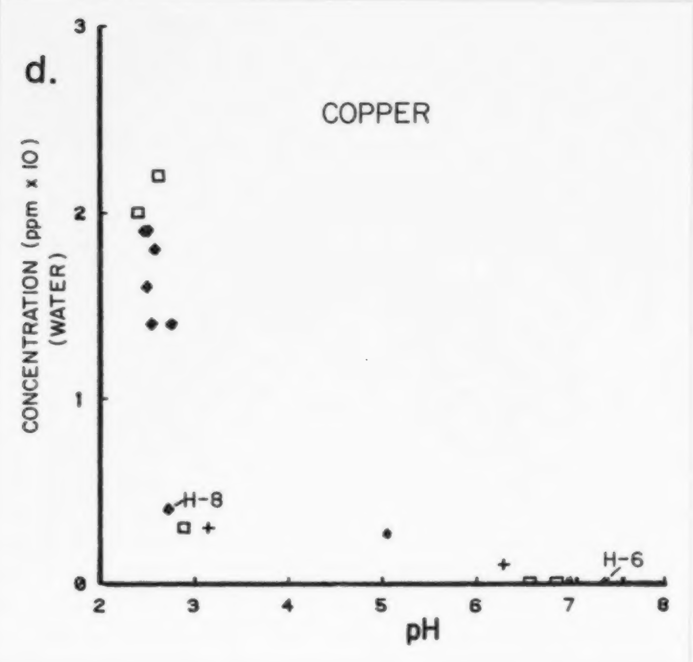

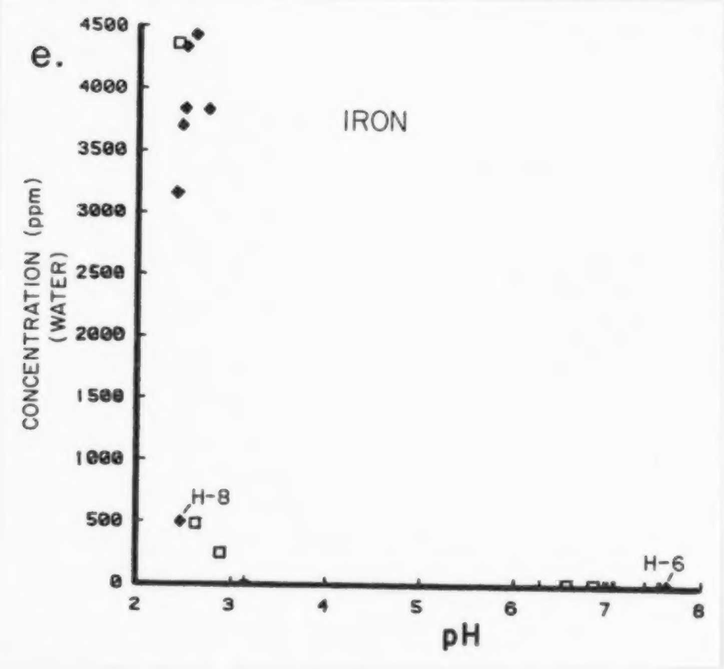

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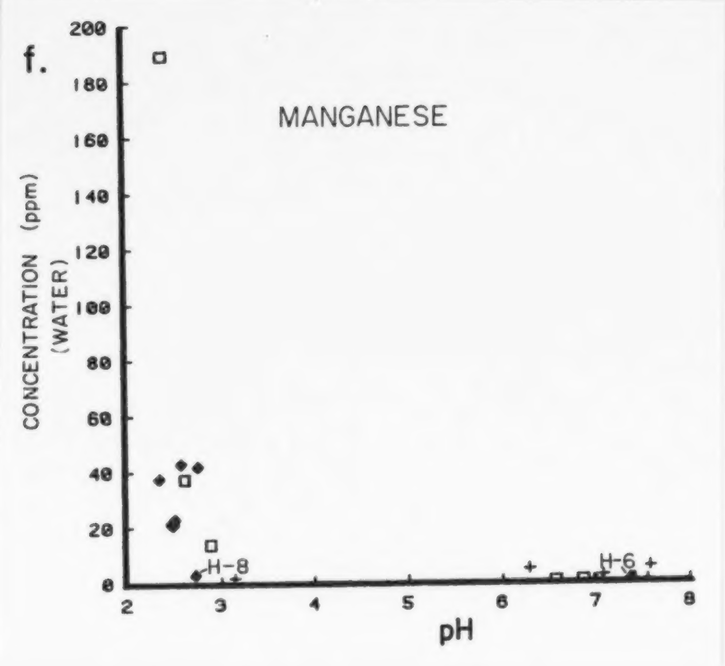

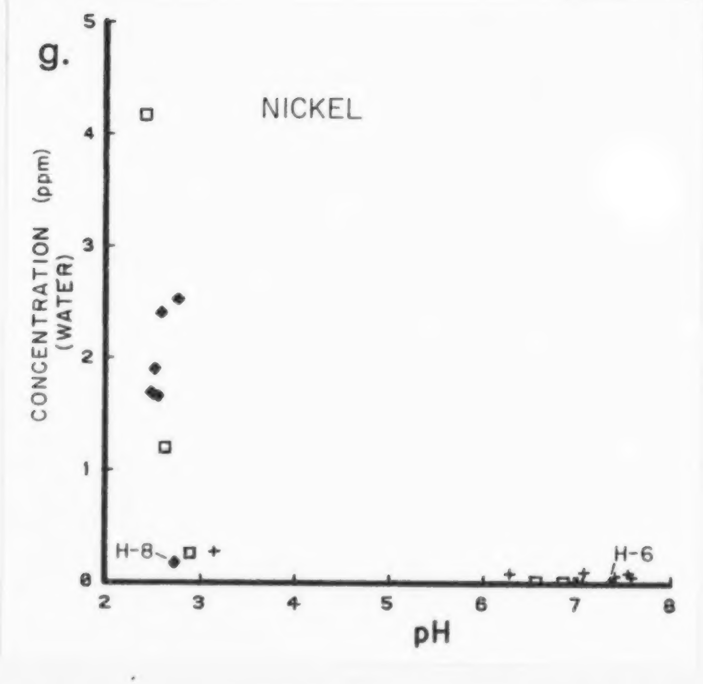

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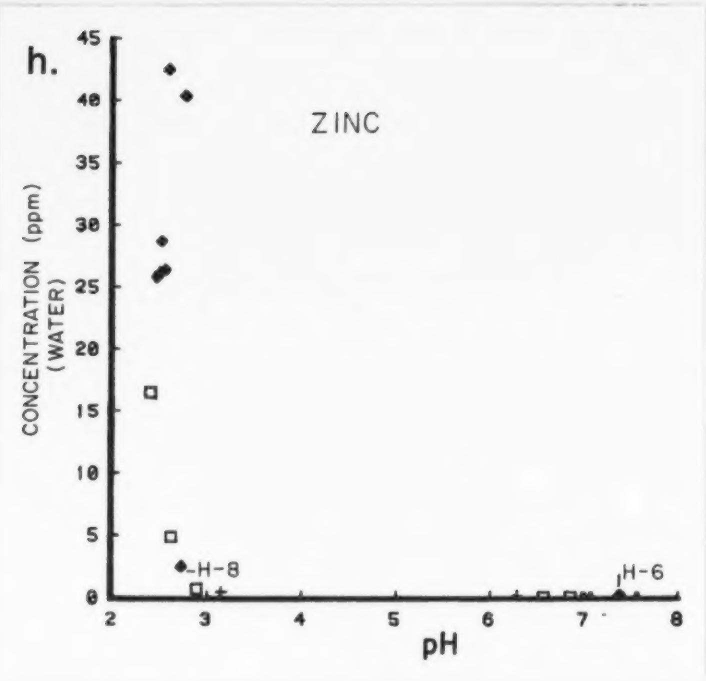

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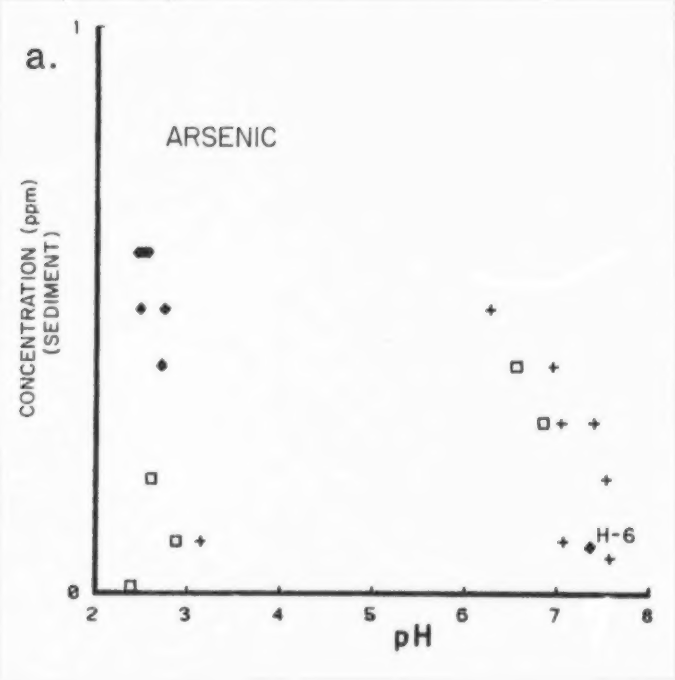
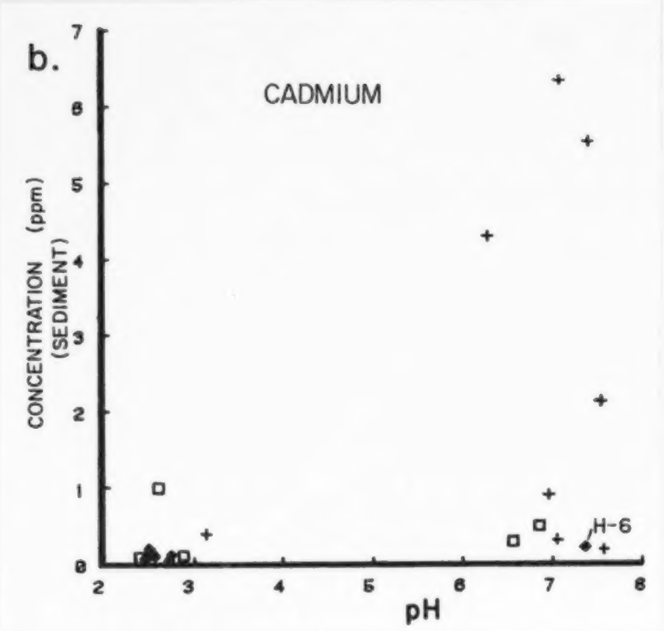
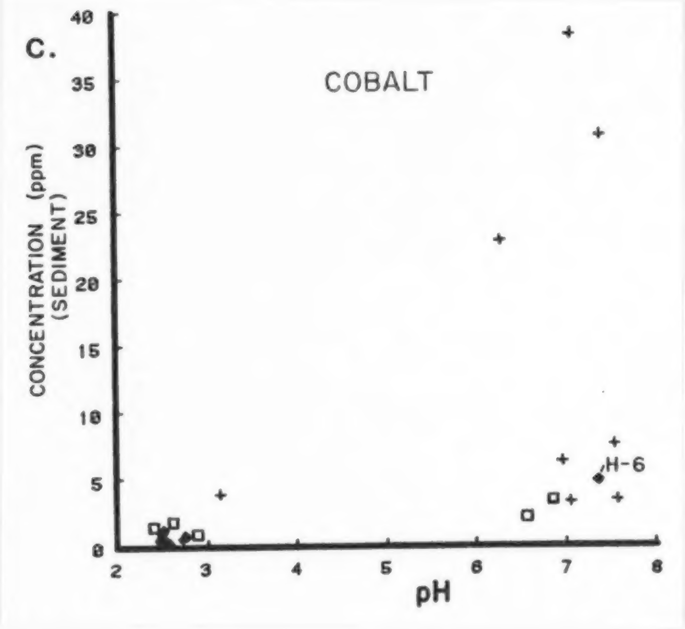


Figure 46. Trace element concentration in sediment vs. pH, all sites.





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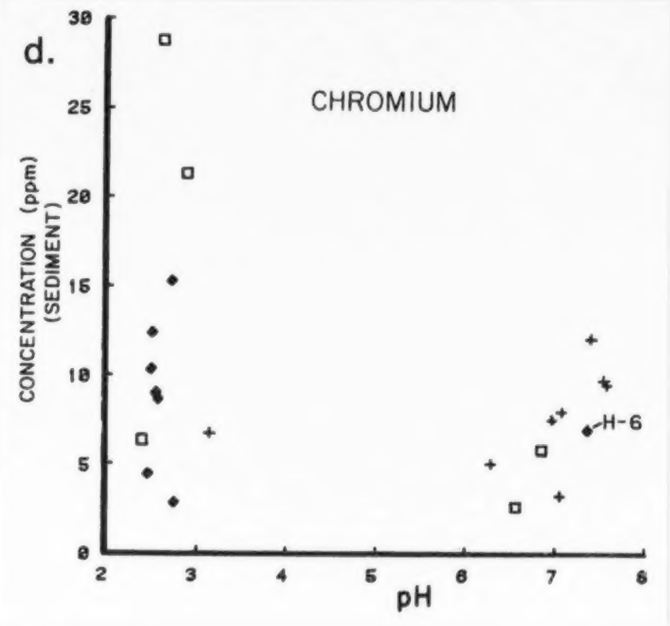

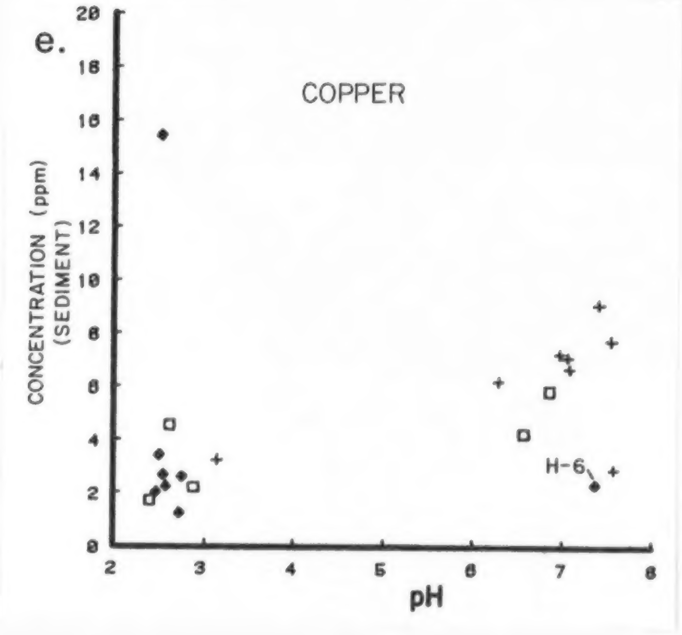

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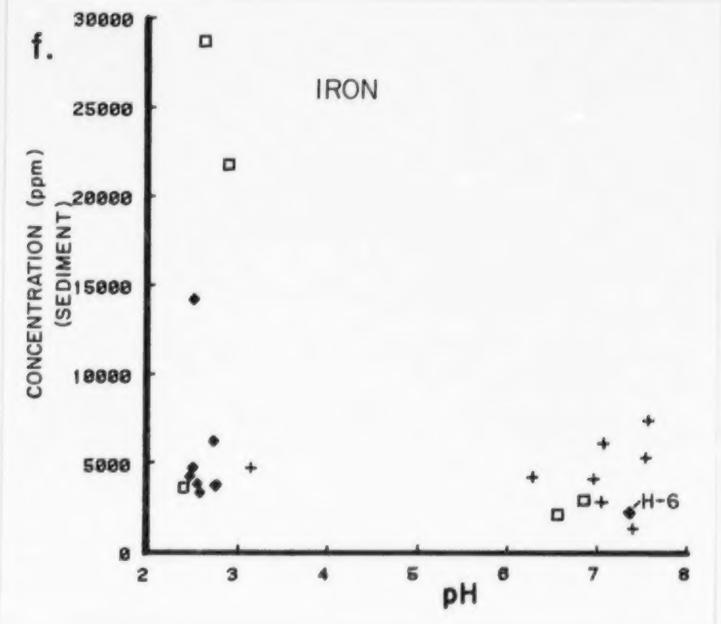

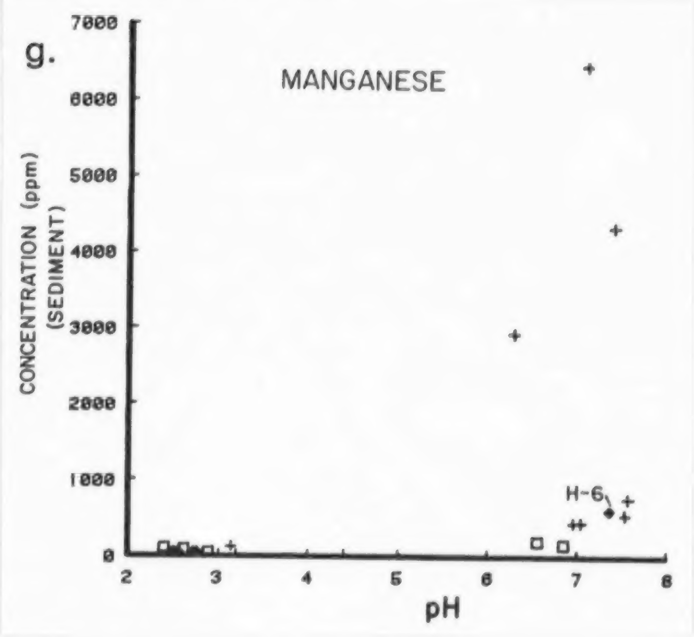

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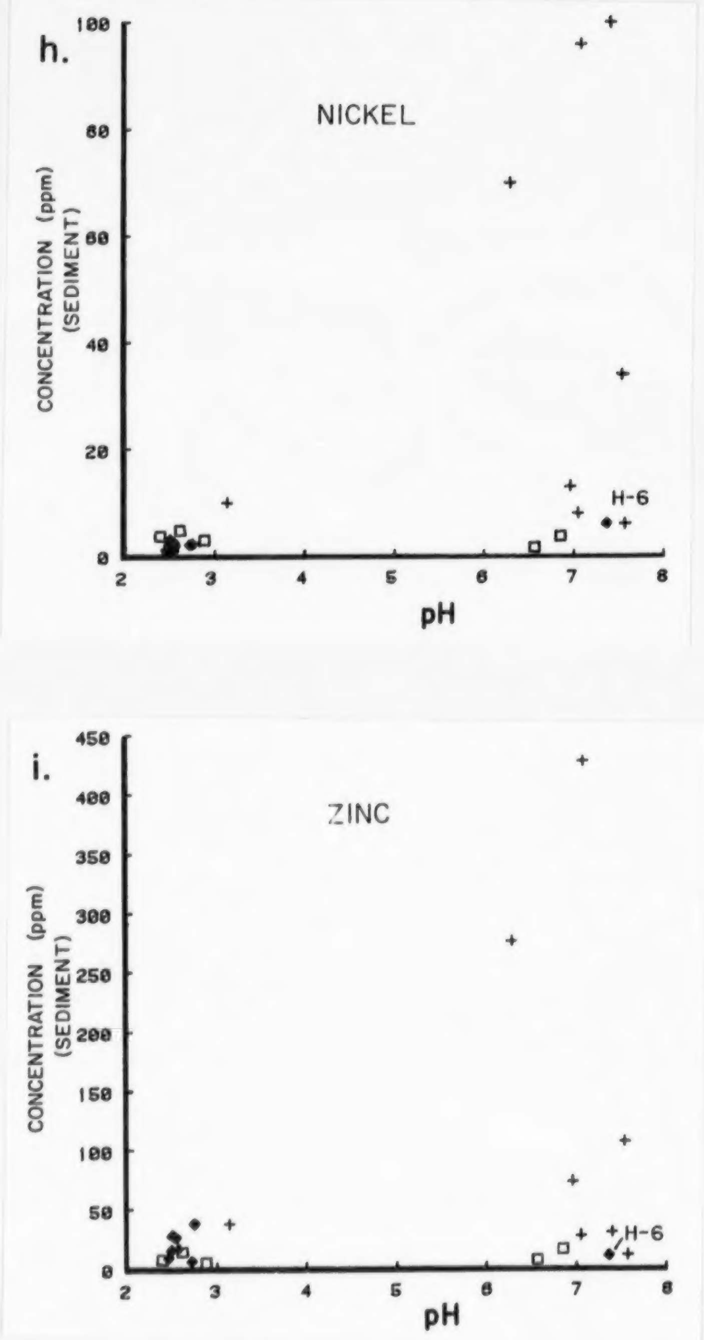

Figure 46 (continued)

Mixing of Harco Branch and Brushy Creek

For all of the elements under consideration, the waters of Harco Branch (H7) carry greater average trace element concentrations than those of Brushy Creek (H6) (Table 9). A simple mixing model of these two streams can be set up by assuming that each of the streams will contribute a given trace element in proportion to the concentration of that element in the stream multiplied by the discharge of the stream, ie., a weighted-average model. Brushy Creek has a larger discharge than Harco Branch; a six-month average based on 15 discharge measurements showed Brushy Creek to have an average discharge of 77.5 lps whereas Harco Branch had 32.5 lps (Hood, 1978). Thus it would follow that after the confluence of the two streams (H8), the mixed water should have concentrations of the various elements more similar to those found in Brushy Creek than in Harco Branch.

TABLE 9. MEAN CONCENTRATIONS (PPM) OF TRACE ELEMENTS IN WATER AND SEDIMENT IN BRUSHY CREEK (H6) AND HARCO BRANCH (H7) ABOVE AND BRUSHY CREEK (H8) BELOW THEIR CONFLUENCE

	Water			Sediment		
Element	H6	H7	H8	H6	H7	H8
As	0.000	0.001	0.000	0.135	0.505	0.351
Cd	0.005	0.056	0.020	0.150	0.084	0.085
Co	0.061	0.481	0.202	3.761	0.651	1.490
Cr	0.024	0.337	0.122	3.894	7.188	6.823
Cu	0.032	0.189	0.110	7.030	2.887	2.651
Fe	61.41	663.1	194.7	3237.0	7166.0	5675.0
Mn	1.203	24.09	10.14	425.1	35.51	95.99
Ni	0.062	1.129	0.408	3.464	1.999	1.915
Zn	0.637	31.82	7.286	8.870	9.159	7.006

Calculations confirm that this is indeed the case (Table 10). If one calculates the average ratio of Brushy Creek water to Harco Branch water needed to give the observed average trace element values below the confluence at H8, a value of 2.35 is obtained (ie., 2.35 times as much water from Brushy Creek). This is almost identical to the value of 2.38 obtained from the discharge measurements and indicates that, for water, the simple mixing model gives a good approximation of trace element behavior. However, some discrepancies do exist. The mixed water is somewhat higher in cobalt, copper, manganese and nickel and lower in iron and zinc than predicted. Zinc is slightly lower than in either contributing stream.

As a first approximation, it should be possible to apply the same mixing model to the sediments. The channel characteristics and slopes of the two streams are similar, as are the soil types, nearby vegetation and general land use. This would suggest that the sediment loads of the streams might well be proportional to their discharges. However, when the simple mixing model is applied to the sediment, there are much larger discrepancies than in the case of water (Table 10). Cadmium, cobalt, copper, manganese, nickel and zinc are all less than predicted and arsenic, chromium and iron are all greater. Copper, nickel and zinc are all less than in either contributing stream. Unlike the case of water, where the magnitude of the discrepancies is generally small, these values all deviate from the predicted value by no less than 22 percent.

TABLE 10. PREDICTED AND OBSERVED TRACE ELEMENT CONCENTRATIONS (PPM) USING WEIGHTED AVERAGE MIXING MODEL

Element	Water (Predicted)	Water (Observed)	Sediment (Predicted)	Sediment (Observed)
As	0.000	0.000	0.24	0.35
Cd	0.020	0.020	0.131	0.085
Co	0.19	0.20	2.84	1.48
Cr	0.12	0.12	4.87	6.82
Cu	0.08	0.11	5.80	2.65
Fe	239.3	194.7	4399.0	5675.0
Mn	7.96	10.14	309.9	95.99
Ni	0.38	0.41	3.03	1.92
Zn	9.85	7.29	8.96	7.01

Because six of the nine values are less than predicted, one might conclude that there should be a better fit if a different mixing factor were used for the sediment. However, there is no consistent factor that one can use to correct the values. If the percent of Brushy Creek sediment needed to get the observed values are calculated, the results vary from 11.1 to 41.7 percent (Table 11). Note that three of the values are meaningless, ie., there cannot be greater than 100 percent of sediment from one creek nor can there be a negative contribution from a creek. All of these elements are subject to various geochemical processes which might change their concentrations in water or sediment and there is no logical reason to assume any one of the mixing factors of Table 11 is any more valid than that calculated from the discharges. Accordingly, it seems reasonable to the authors to try to explain the observed changes based on a simple mixing model weighted according to discharges.

TABLE 11. PERCENT OF BRUSHY CREEK SEDIMENT NECESSARY TO GIVE OBSERVED VALUES IN MIXING ZONE

Element	Percent	Element	Percent
As	41.7	Fe	37.9
Cd	1.5	Mn	15.5
Co	27.0	Ni	-5.7
Cr	11.1	Zn	745.0
Cu	-5.7		

Earlier it was observed that cobalt, copper, manganese and nickel all have lower concentrations in the sediment and higher concentrations in the water than predicted. This strongly suggests that these elements are dissolving from the sediment and going into solution. Iron, on the other hand, is lower in the water and higher in the sediment, suggesting that this element is precipitating. Zinc is a problem because it is lower in both sediment and water than predicted. However, there is one value for zinc in Harco Branch (week of June 4) that greatly increases the average for that stream. If this value is discarded and a new predicted value for zinc in water is calculated, the result is 6.13 ppm, which is less than the observed value. This eliminates the problem of the disappearing zinc and indicates that zinc is also dissolving from the stream sediment. Both copper and nickel are also present in the sediment below the confluence in lower concentrations than in either contributing stream, reinforcing the conclusion that these elements are dissolving.

The explanation for the precipitation of some elements and the simultaneous dissolution of others is related to the pH of the waters. Values for pH cannot be directly averaged because pH is logarithmic. However, median values (half above, half below) can be determined, and the pH of waters resulting from mixing can be calculated. The pH values are converted back to activity in order to do the calculations and then subsequently reconverted to pH. The median values for Brushy Creek, Harco Branch and Brushy Creek below the confluence are 7.00, 2.62 and 2.92, respectively. Calculating the weighted predicted median value for pH of the mixed water gives 3.15, considerably higher than observed. The higher predicted pH value is consistent with the precipitation and dissolution of elements described earlier. Iron is by far the most abundant of the elements examined in this study. When iron is oxidized in an aqueous environment, it hydrolyses and produces a precipitate, ferric hydroxide, along with hydrogen ions that are released into the water:

$$Fe^{+2} + 3H_2O = Fe(OH)_3 + 3H^+ + e^-$$

The precipitate will settle to the bottom and become part of the sediment, thereby lowering the values in water and raising those in the sediment. The hydrogen ions released will make the water more acidic than predicted by the simple mixing model, and the low pH of the water will be conducive to dissolving elements more soluble than ferric iron. The evidence found in this study indicates this is exactly what is happening at the confluence of Brushy Creek and Harco Branch, with several trace elements being mobilized from the sediment of Brushy Creek when the water is made acidic by the contributions from Harco Branch.

S-SERIES

In order to compare the trace element behavior between two different streams, the S-series sampling sites (Figure 47) will now be examined. The sites of the S-series are located on two streams, the South Fork of the Saline River and Sugar Creek, both of which have greater discharges than the previously discussed Harco Branch. Values for trace element concentrations at different sites of the S-series are not as consistent as they are for the H-series, especially when compared to those of Harco Branch itself. There are rapid downstream changes in pH within Sugar Creek, which also contrasts with Harco Branch. Another difference between the two series is that in the H-series 90 percent of the abnormally high values occurred between June and October, whereas in the S-series only 63 percent of the high values occur in this time interval. One reason for the difference is that in the S-series many high values occur in November; another is that there are more sampling sites (two out of five) that have no seasonal trend. Thus, high values are scattered throughout the year.

Seasonal Variation

To illustrate the seasonal trends observed in the S-series, only the element nickel will be used (Figure 48). This is because there is such a high positive correlation among the various trace elements that any one is representative of the others.

Sites S-1 and S-2, located on the South Fork of the Saline River and on Sugar Creek, respectively, are both upstream from significant coal mining activity. Neither of these sites shows a seasonal trend in trace element concentration in the water (Figures 48a and b). Both have low concentrations of nickel, with mean values of 0.04 and 0.06 ppm, respectively. The lack of a seasonal trend and low concentration are features also found in Brushy Creek of the H-series. The features that these two sites have in common with Brushy Creek is that they are all upstream from mining and all have pH values in the range of 6 to 7.

Site S-3 is located downstream from S-2 on Sugar Creek. In contrast to site S-2, this site typically has a very low pH value, much higher concentrations of nickel (1.16 ppm mean value), and a distinct seasonal trend (Figure 48c). The seasonal trend is similar to that of Harco Branch, with the higher concentrations occurring from June to November. A slight deviation from the H-series is present in the appearance of two distinct levels of higher concentrations in the summer and fall months. The smaller increase in concentration occurred in June and continued through August. Then another sharp increase occurred in September, followed by an equally sharp drop in November. This two-stage increase was not observed at any other site, although all of the elements examined exhibited the dual increase at site S-3 (Figure 49).

Sites S-4 and S-5 are located on the South Fork of the Saline River, below its junction with Sugar Creek. Thus, they are downstream from the juncture of a stream with normal pH (South Fork, site S-1) with one having low pH (Sugar Creek, site S-3). Both sites S-4 and S-5 exhibit a seasonal trend, which begins with high concentrations in June and decreases again in November (Figures 48d and 48e). This trend is more similar to the Harco Branch trend than that of the contributing waters of S-3. These two sites both have pH values in the range of 2 to 4, comparable to Harco Branch. There is a marked change in the nickel concentrations between the sites. Site S-4 has high values, with a mean of 3.24 ppm; S-5 is relatively low with a mean of 0.23 ppm. When considered together, the S-series sites reinforce the previous observation from Harco Branch that only those sites with low pH tend to have seasonal concentration variations.

In the H-series, it was observed that rainfall had a relatively small influence on trace element concentrations. A greater influence was observed in the S-series. For example, when the cobalt concentrations are superimposed on the rainfall histogram (Figure 50), they show a stronger relationship than that of the H-series. The concentrations are roughly in inverse proportion to the rainfall, both in major trend as well as in the minor fluctuations. Because rainfall amounts in the two study areas are similar throughout the year, the effect of rainfall on trace element concentrations must depend on characteristics of the streams themselves. The drainage area of Sugar Creek above site S-3 is far greater than that of Harco Branch. For the only time period that discharges are available for both streams, they had average discharges of 66.3 lps and 32.6 lps, respectively (Hood, 1978). The probable reason that this site shows greater influence of rainfall is that the greater upstream catchment area and discharge allows for more dilution of the mine effluent by purer upstream water than occurs in the H-series.

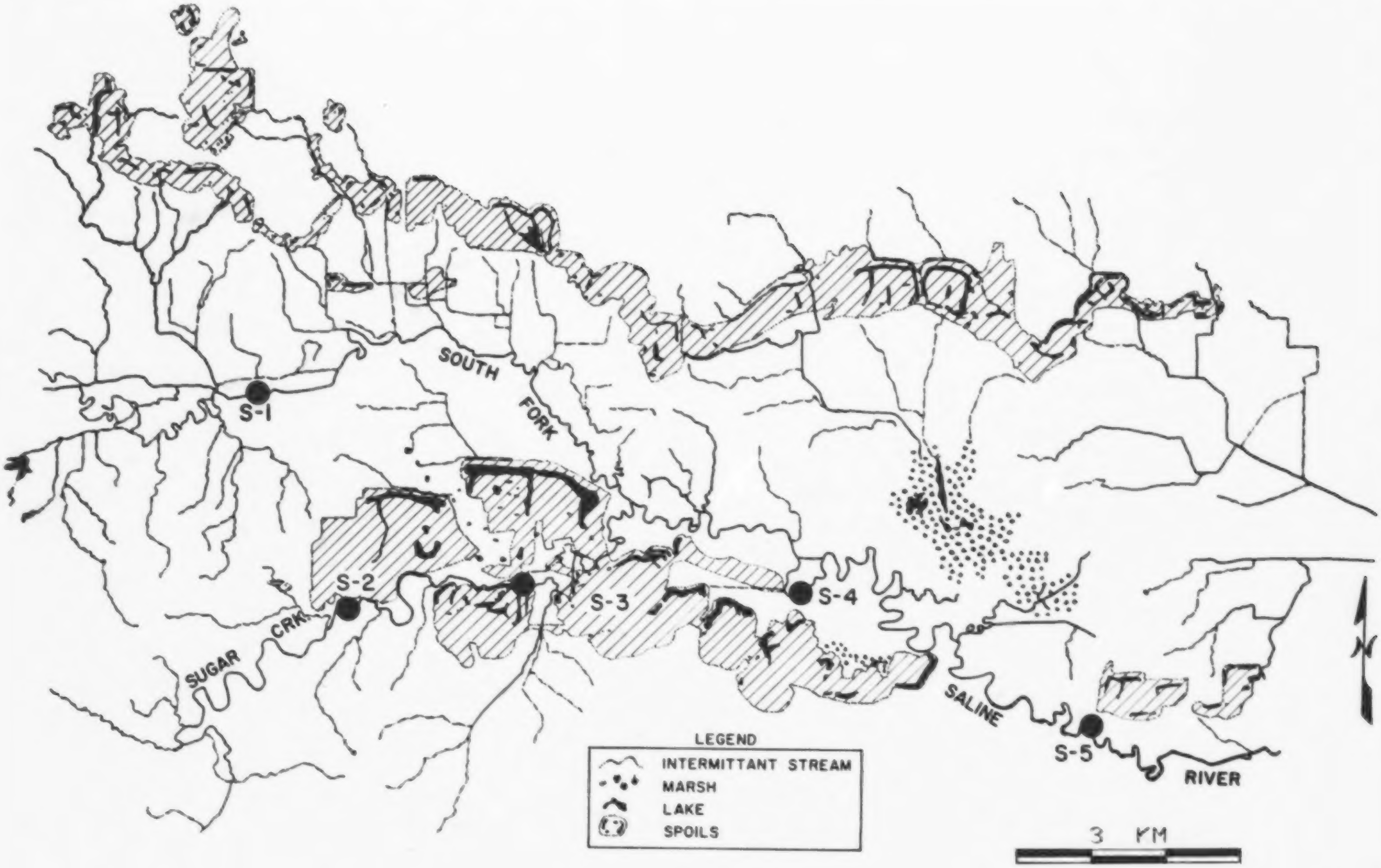
S-1
S-2
S-3
S-4
S-5
SOUTH FORK
SUGAR CRK
SALINE RIVER
N
LEGEND
INTERMITTANT STREAM
MARSH
LAKE
SPOILS
3 KM

Figure 47. Map of S-series.

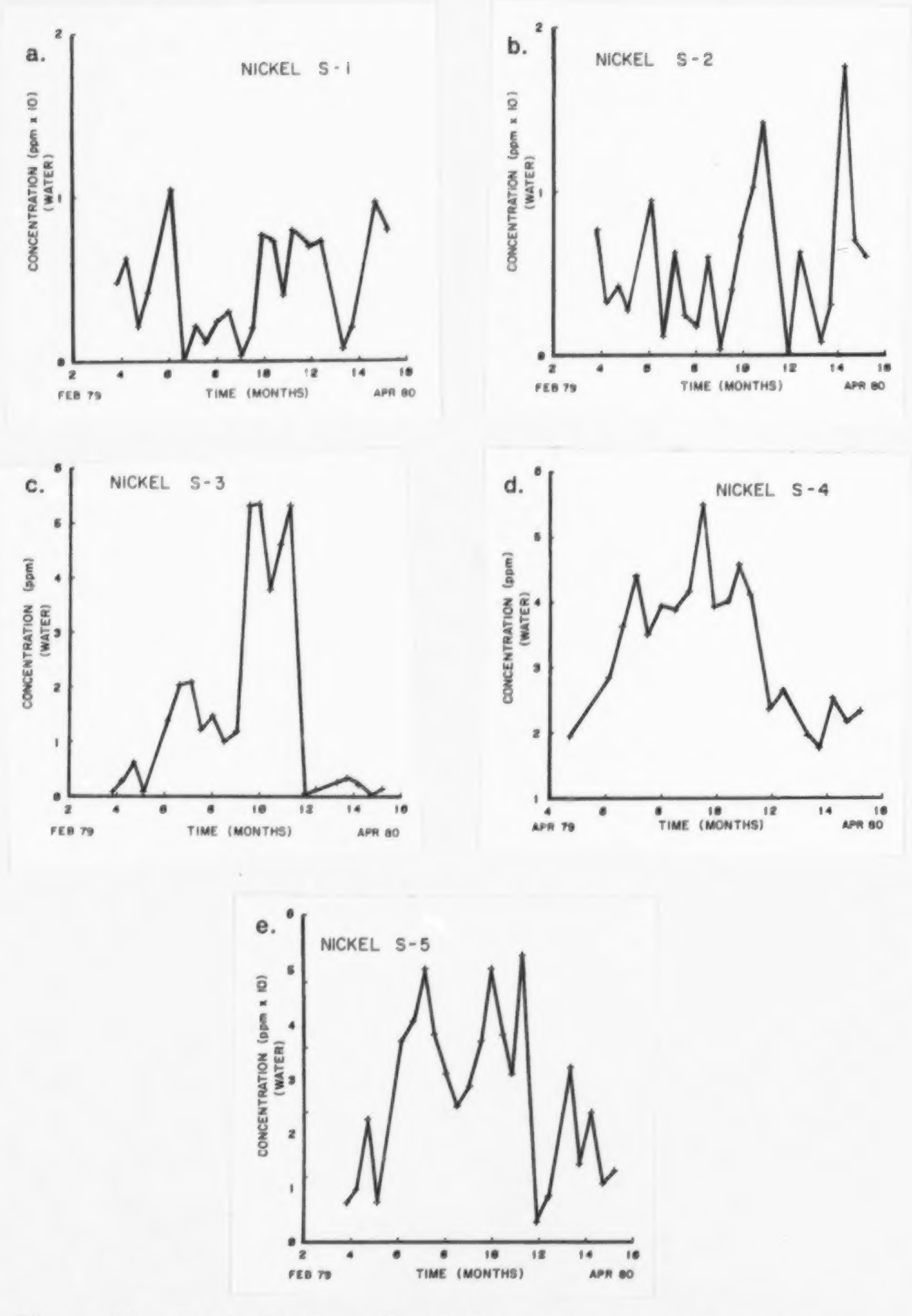

Figure 48. Concentration of nickel in water vs. time, S-series.

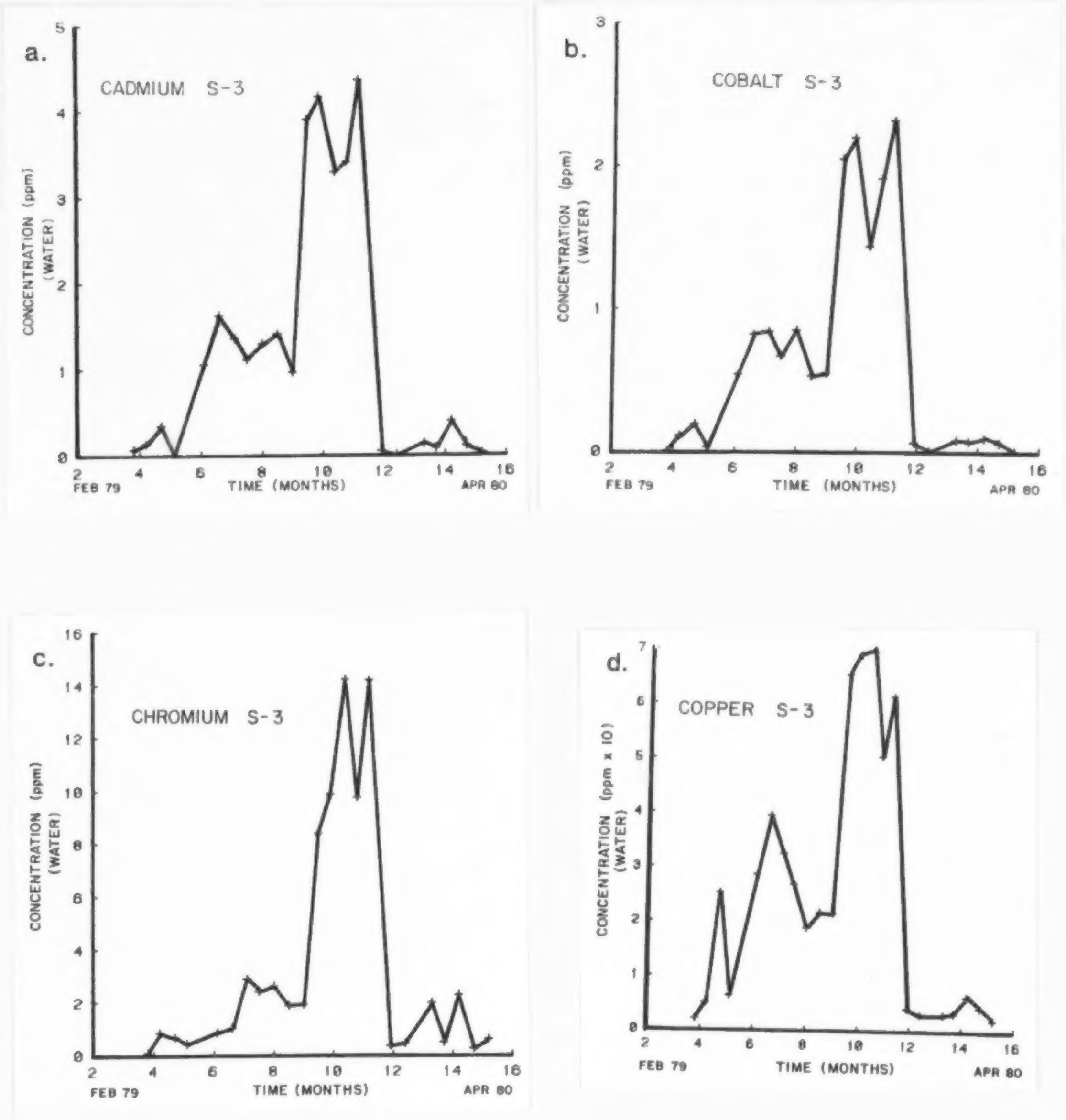

Figure 49. Trace element concentrations in water vs. time: site S-3.

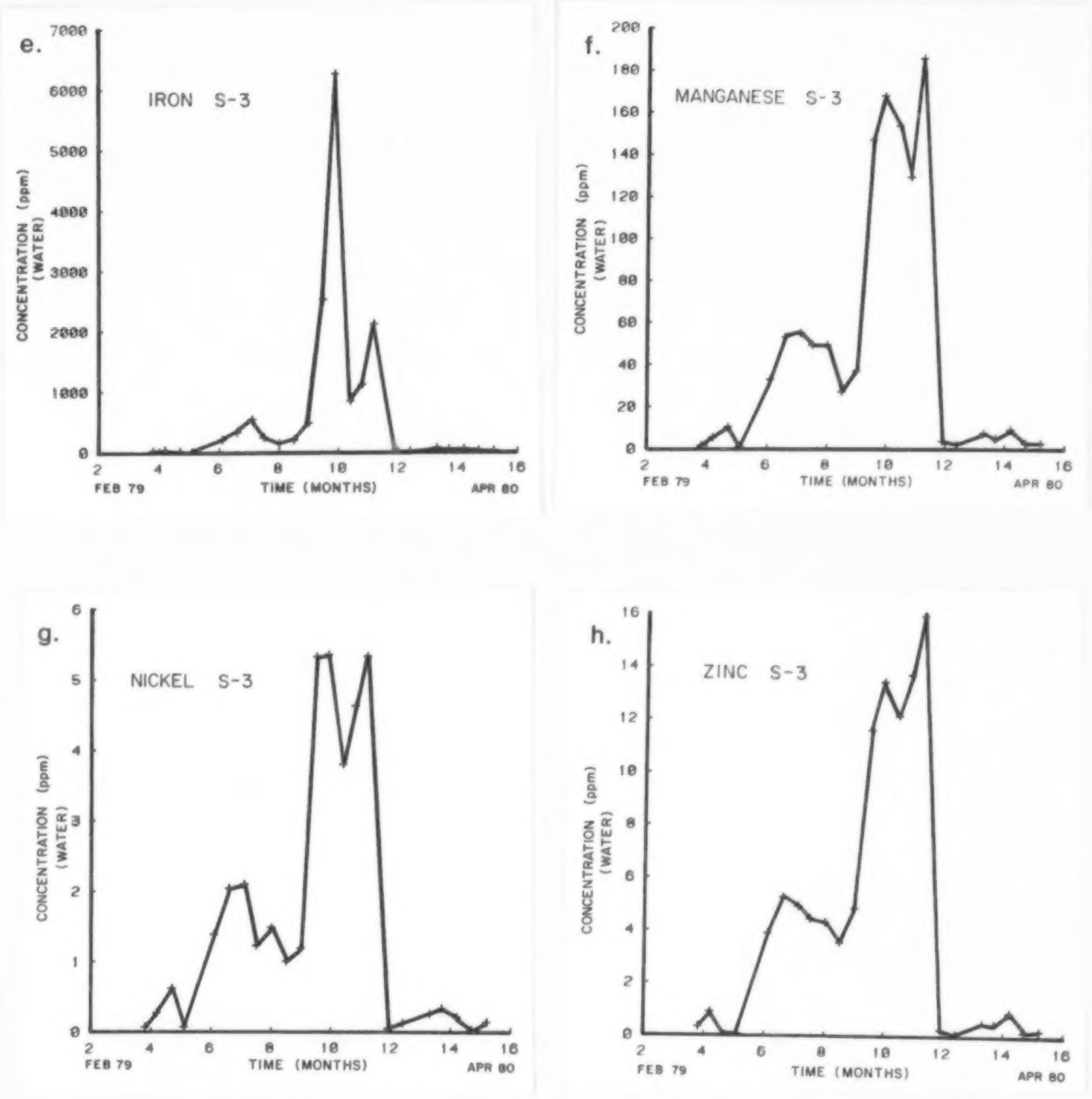

Figure 49 (continued)

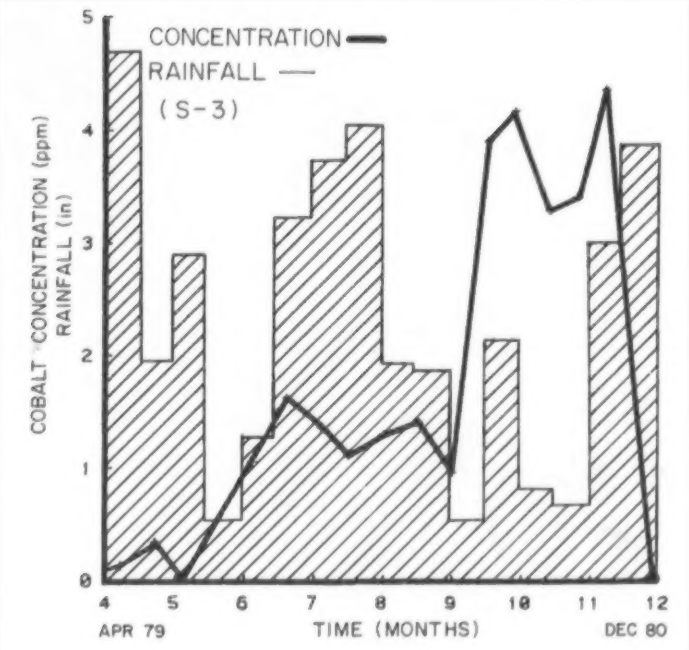

Figure 50. Concentration of cobalt in water vs. amount of rainfall, April through December.

Downstream Variations in Trace Element Concentrations

In this section, the concentrations of trace elements in the water and sediments of the S-series will be examined. Because there is not a single stream with a series of stations that can be conveniently illustrated by plotting concentration vs. absolute distance, the downstream variation will be illustrated by plotting the points in relative position to one another, ie., plotted in a downstream direction but without a distance scale. There will be special reference to sites S-4 and S-5, which are located after the confluence of the South Fork and Sugar Creek. The South Fork of the Saline River has a greater discharge than its tributary, Sugar Creek, with average discharge during the six month interval when comparable measurements are available of 271 lps and 66.3 lps, respectively (Hood, 1978). Simple mixing of these two waters should result in values much more like the low values of site S-1 on South Fork than site S-3 on Sugar Creek.

Water--

In each case, the trace element concentrations for the upstream site S-1 and S-2 are very low, almost always being less than 1 ppm. At site S-3 just below the old Palzo Mine, there is a striking increase in the trace element concentrations in Sugar Creek (as well as the previously mentioned sharp decrease in pH). Below the confluence of the two streams (site S-4), the mean values of all but two of the trace elements in water are higher than at either upstream site (Figure 51). Of the two exceptions, arsenic is present in concentrations so low that they cannot be reliably interpreted, and copper is the only element with an intermediate value after mixing of the two streams. Subsequently, there is a rapid drop in trace element concentrations so that the furthest downstream site (S-5) has concentrations similar to those of the upstream sites.

There are several possible explanations for the increase in trace element concentrations below the confluence. First of all, the low pH of the mixed water may be dissolving additional trace elements from stream sediment. Second, site S-4 is not located immediately below the confluence but rather is 1.5 kilometers downstream, so that other, unobserved phenomena may be influencing the water below the junction. Third, there may be some sort of sampling bias because of the somewhat stagnant nature of the stream at this site.

Sediment--

After the confluence of South Fork and Sugar Creek, the mean values for arsenic, cadmium, cobalt, copper and zinc in sediment are all lower than either contributing stream (Figures 52a, b, c, e and i). Manganese also has a very low value, much lower than South Fork and barely exceeding Sugar Creek (Figure 52g). Only chromium, iron and nickel show the intermediate values expected by simple mixing (Figures 52d, f, and h).

At site S-5, the second site beyond the confluence, there is an increase in trace element concentration of the sediment when compared to S-4 for all elements except nickel. Nickel concentrations at the two sites are almost identical.

Discussion of Downstream Variations

The strong increase in trace element concentration in water from S-2 to S-3 on Sugar Creek is quite easily explainable by the influx of mine effluent to the creek from the Palzo Mine, long recognized as a major source of pollutants in the area. Similarly, the increase in trace element concentrations in the stream sediment at this site can be explained by precipitation of some of the contaminants in the mine effluent as the very acidic effluent is partly neutralized by the purer upstream waters of Sugar Creek. At site S-4, however, the known aqueous source of trace elements, ie., the Palzo Mine effluent, has been left far upstream, yet the trace element concentration in the water increases. Concurrent with the increase in aqueous trace element concentrations, there is a corresponding decrease in trace elements in the stream sediment. These changes are impossible to explain by any sort of simple mixing model, because such a model would require the mixture to have values somewhere between the two mixing waters. This is not the case, either in the water or the sediment. In most instances, the values are either greater (in the case of water) or less (in the case of sediment) than possible by mixing. Even in those cases where concentrations are intermediate, simple mixing is an unsatisfactory explanation of observed values. Using manganese as an example, the amount of manganese in the sediment, after mixing, much more closely resembles the manganese concentration of the acidic Sugar Creek sediments (468 ppm from South Fork, 84 ppm by Sugar Creek and 92 ppm after the confluence). If the amount of sediment moved by the streams has any relationship to the discharge, one would expect nearly four times as much of the South Fork sediment, with higher manganese concentration. The mixed sediment should be much closer to 468 ppm than to 84 ppm, yet just the opposite is true. In the case of iron, another of the few elements with intermediate values below the confluence, concentrations in sediment resemble the low pH stream, Sugar Creek. Below the confluence, the mean iron concentration is about 9,000 ppm, much closer to the 12,200 ppm value of Sugar Creek than to South Fork with 2,900 ppm.

Although the evidence is somewhat circumstantial, when taken as a whole the most probable explanation for the observed behavior of the trace elements in the water and sediment below the confluence of a low pH stream and a normal one is that the low pH of the resulting water is allowing the dissolution of trace elements from the stream sediment and releasing them to the water. Below site S-4, the concentrations of the elements in water decrease and those of the sediments increase, indicating that the elements are once again precipitating and becoming part of the sediment load of the stream. Thus it appears that acidic waters entering a stream can mobilize trace elements from a stream sediment, and that with time and downstream transport, the mobilized elements can once again be removed from the water. The stream is a dynamic entity, increasing or decreasing its trace element load in response to outside factors that change its pH.

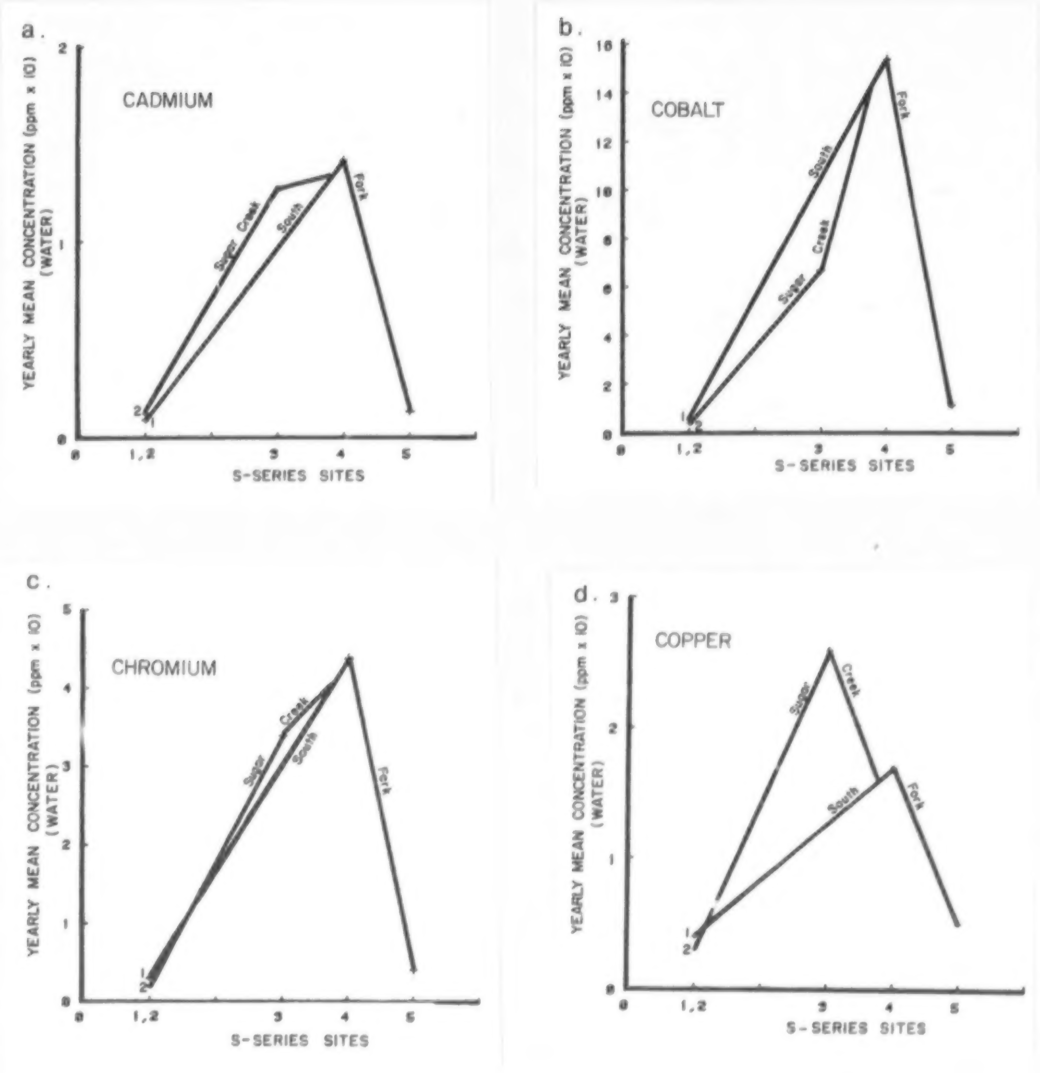

Figure 51. Mean trace element concentrations in water: S-series.

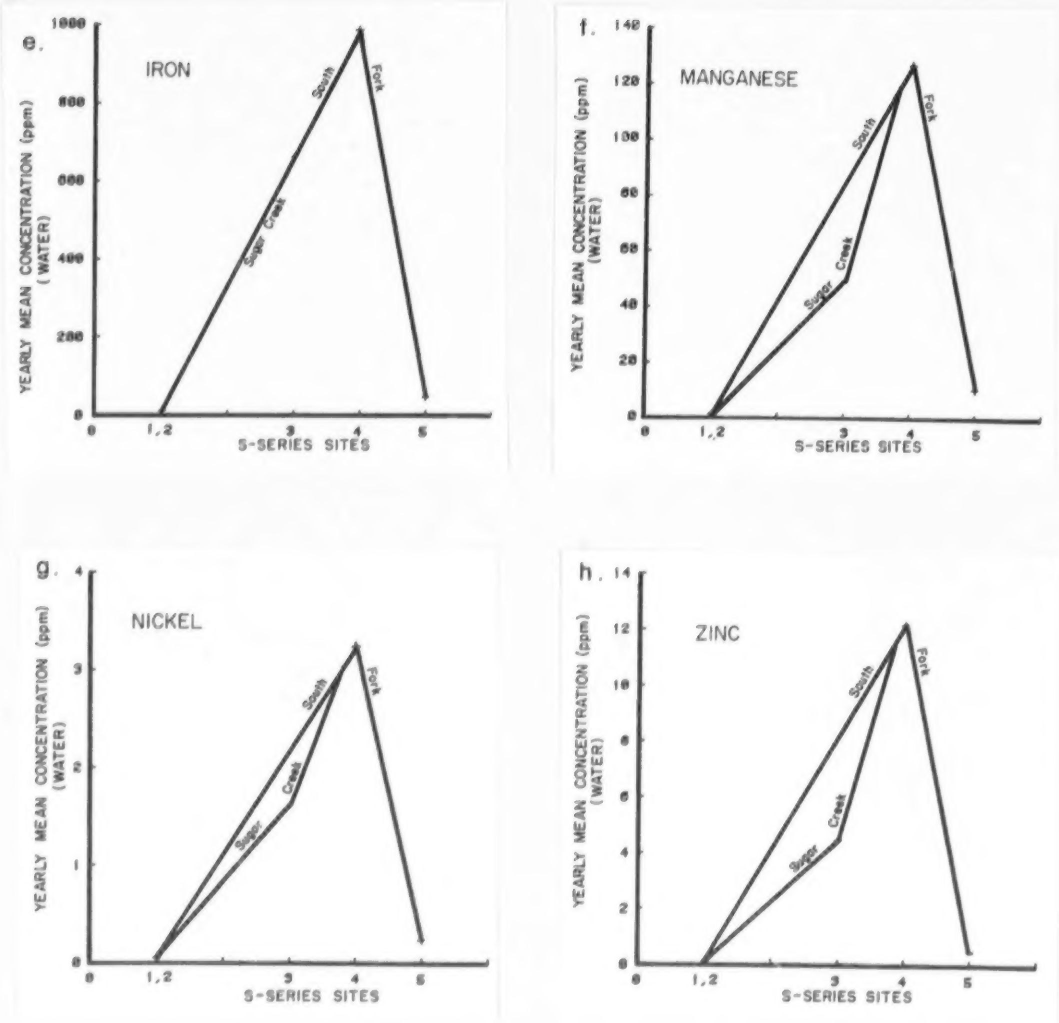

Figure 51 (continued)

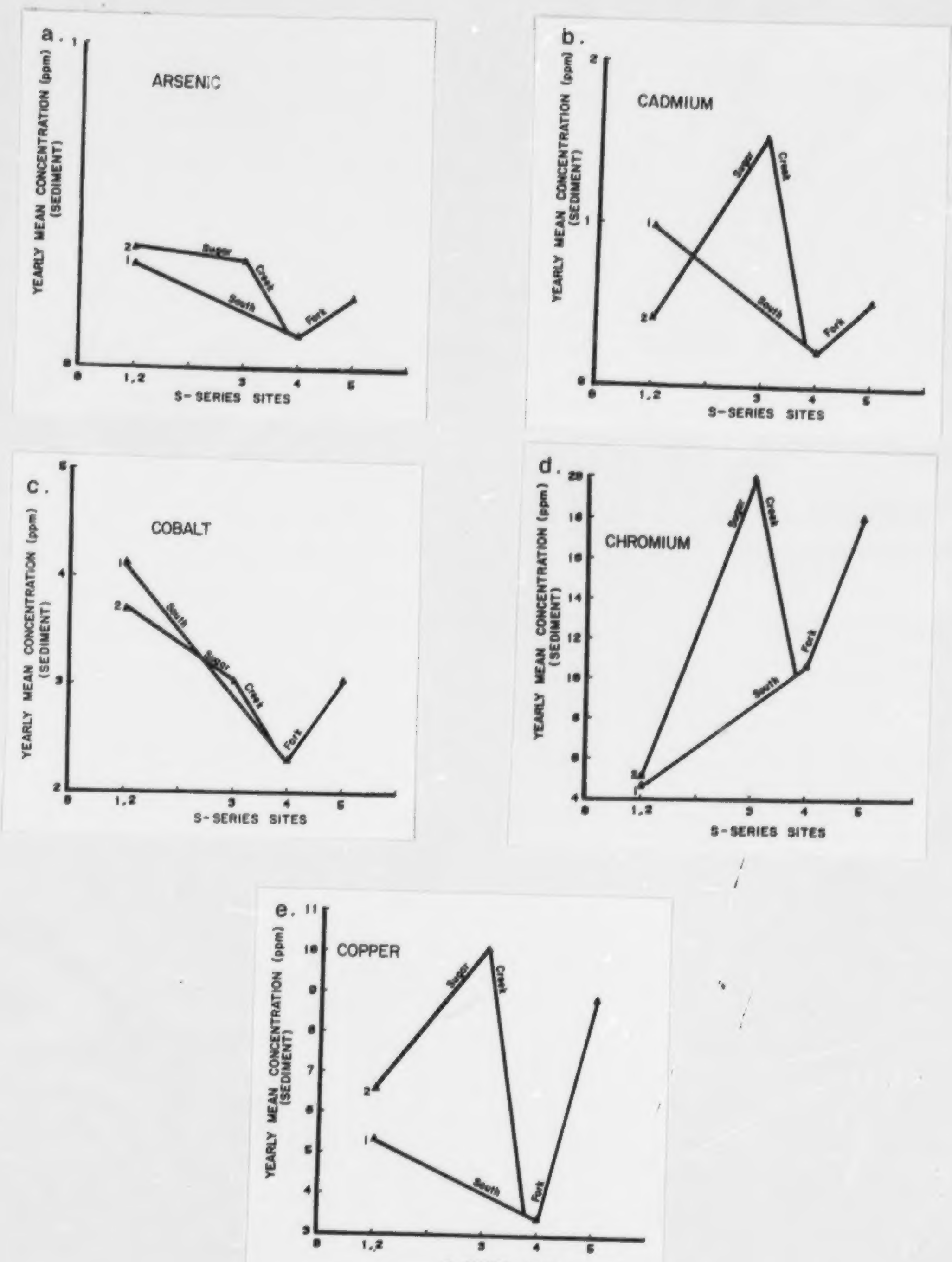

Figure 52. Mean trace element concentration in sediment: S-series.

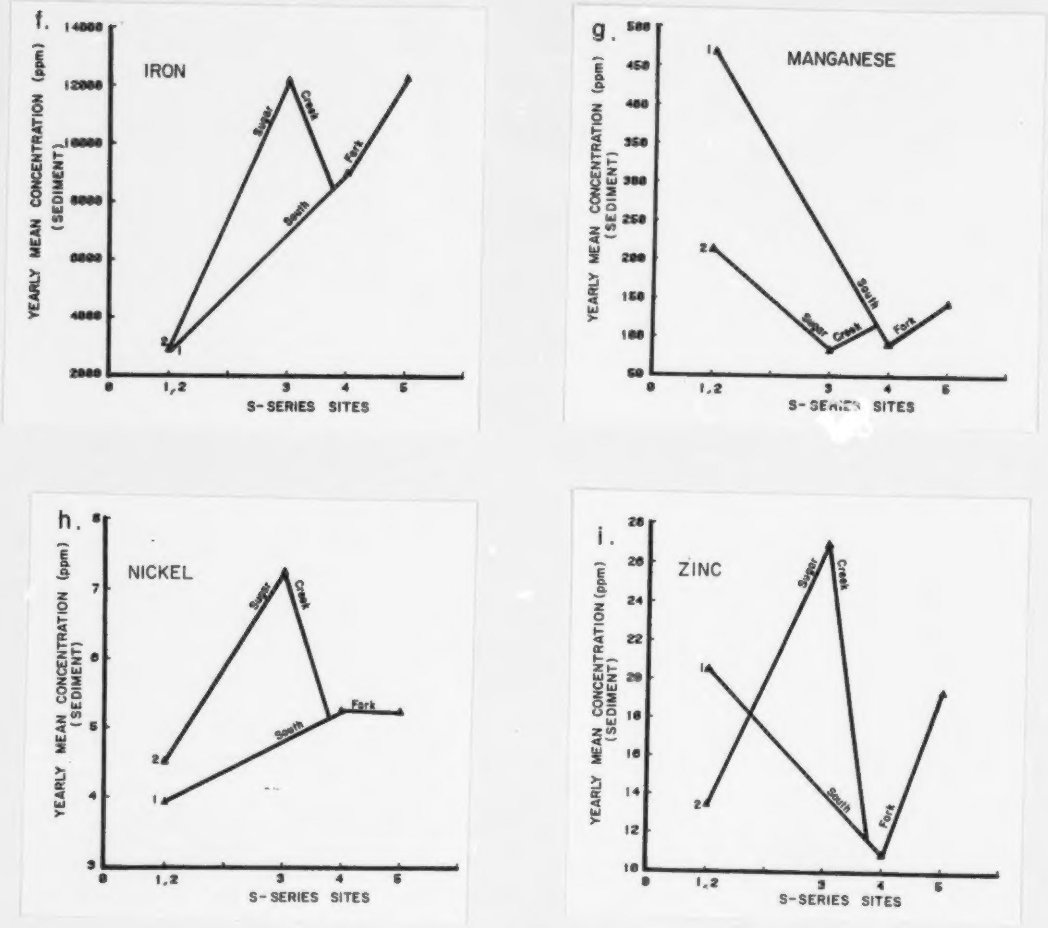

Figure 52 (continued)

C-SERIES

The eight sites of the C-series are located in northwestern Williamson County, about 8 kilometers north-northeast of the city of Herrin, Illinois. The sampling sites encompass about 15 kilometers of stream channels, all of which are tributary to the Big Muddy River. These sites are located in Pond Creek, Lake Creek (both of which are channelized), Bear Creek and an unnamed tributary of Pond Creek (Figure 53). The two sites in closest proximity to coal mining activities are site C-7 on Bear Creek and site C-6 on the unnamed stream. The other sites are downstream from these or monitor streams into which the contaminated streams flow. Two factors distinguish this series from the previously discussed H and S series. First, this is a much more complex stream network, with numerous major and tributary streams in the system. Second, only one of the sites in this series has a low pH (site C-7 on Bear Creek just below old coal mines). This site typically had pH values lower than 4; the others almost always had pH values exceeding 6.

Seasonal Trends

In contrast to the H-series, the waters of the C-series sites typically did not show a seasonal variation in concentrations of trace elements; neither did they show the good interelement correlations observed in the other series. The element manganese is used to show the typical behavior of trace elements at the various sampling sites (Figure 54). Although the lack of a seasonal trend is the salient feature of this series, there are some interesting exceptions. Sites C-4 and especially C-8 on Lake Creek do show somewhat higher values of manganese in the summer months. Both of these sites are atypical for the entire study area inasmuch as they are the only sites that have near-neutral pH values, yet show the tendency to have higher concentrations in the summer months. Site C-7 is also atypical because it has a low pH yet does not show strong seasonal variations in concentration for most elements.

Downstream Variations in Trace Element Concentrations

Downstream changes in concentrations of the trace elements in water and sediment were extensively covered in the discussions of the two other sampling series. There are no comparable long distance downstream relationships that can be examined in the C-series. However, when two or more sites are located on the same tributary they exhibit similar behaviors so that some shorter groupings of sites can be used to develop a general idea of the behavior of the trace elements in this area.

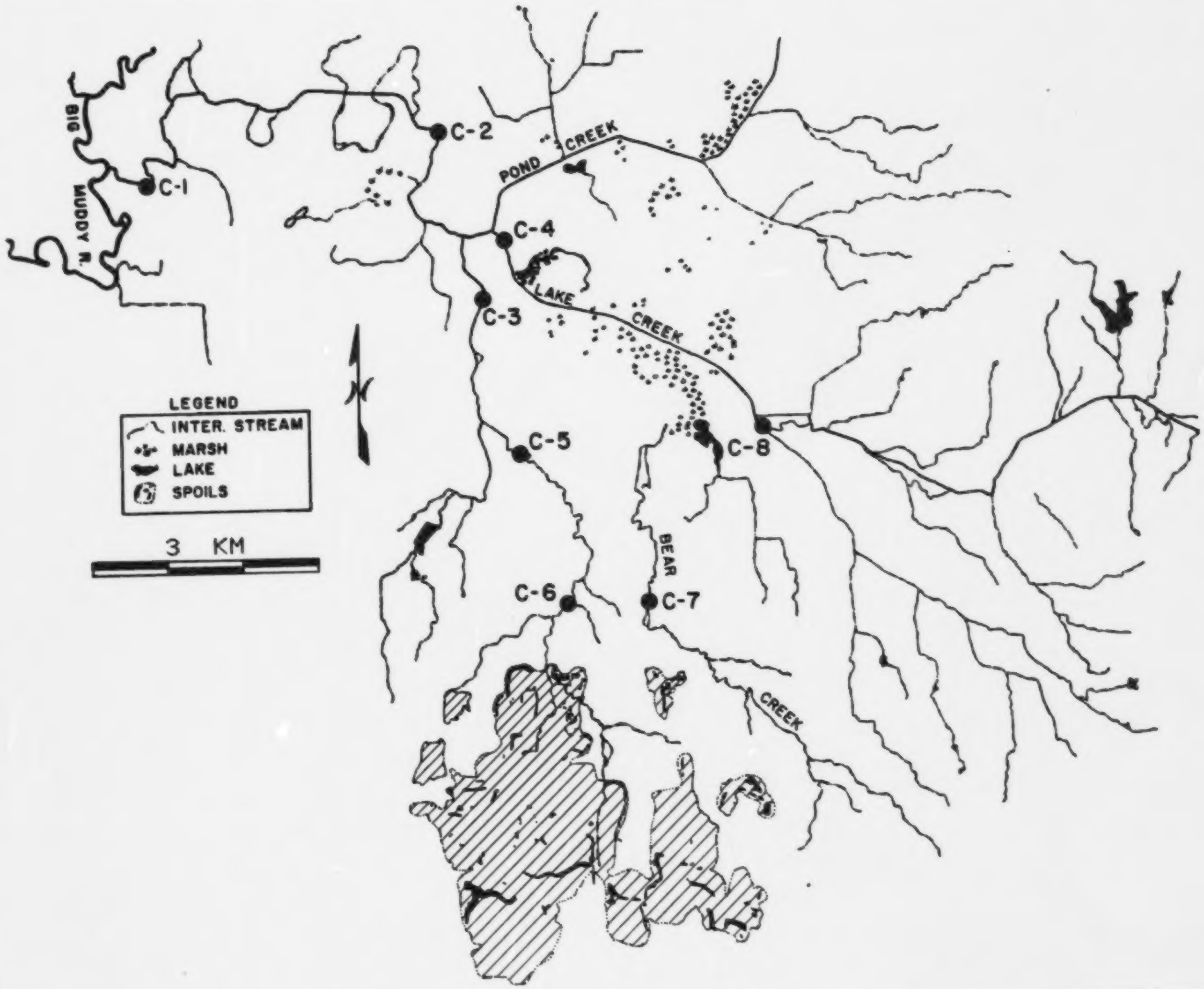
BIG
MUDDY R.
C-1
C-2
POND
CREEK
C-4
LAKE
CREEK
C-3
C-5
C-8
BEAR
C-6
C-7
CREEK
LEGEND
INTER. STREAM
MARSH
LAKE
SPOILS
N
3 KM

Figure 53. Map of C-series.

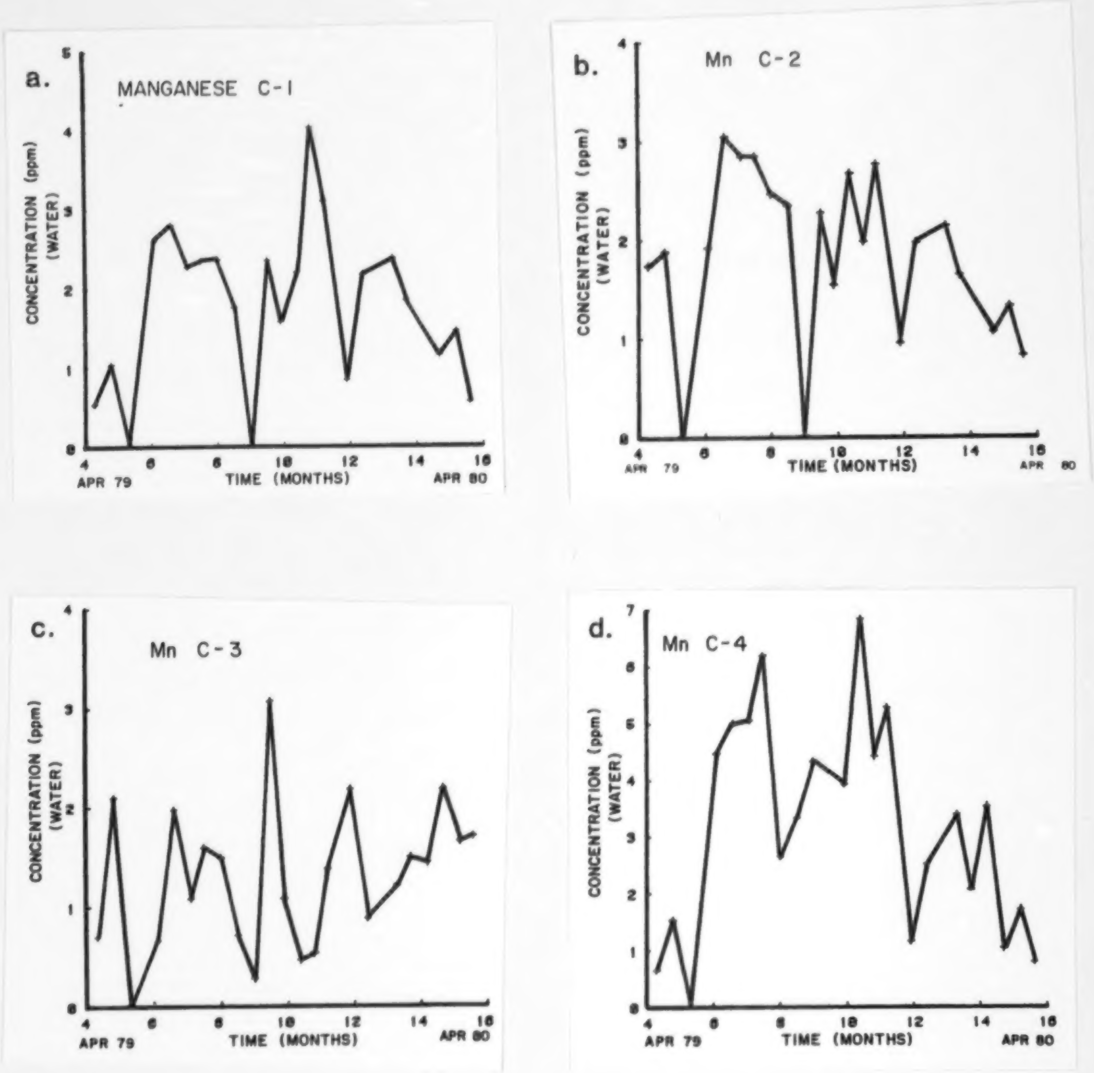

Figure 54. Concentration of manganese in water vs. time: C-series.

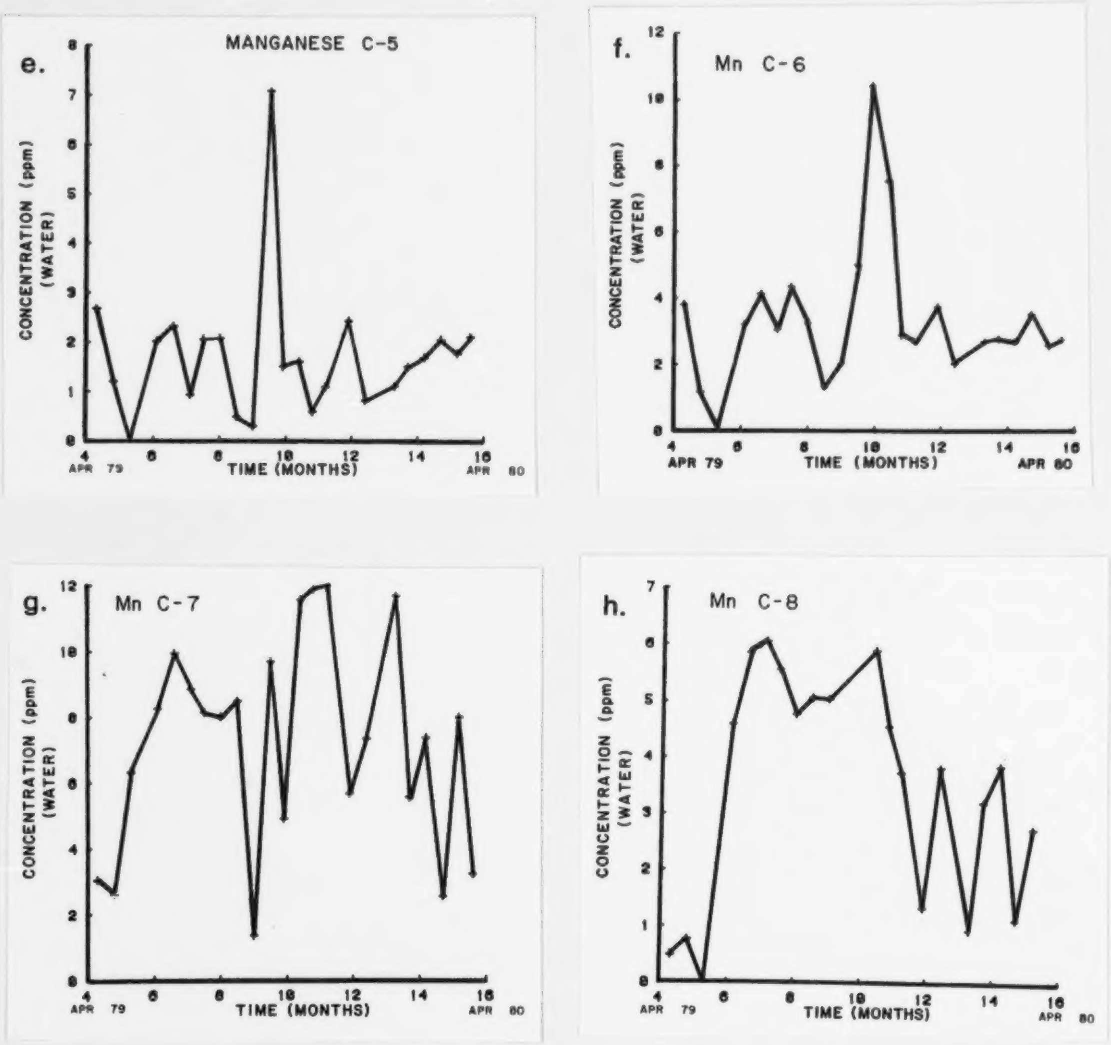

Figure 54 (continued)

Sites C-6, C-5, and C-3--

Sites C-6, C-5 and C-3 are all located on the same unnamed tributary of Pond Creek. Site C-6 is farthest upstream and is roughly one-half kilometer below an old coal mine; C-3 is located farthest downstream, below the confluence of a very small tributary.

In the case of water, there is comparable behavior for most of the elements between this part of the C-series and the H and S series. Below the mine, mean trace element concentrations in water decrease downstream, with six out of eight elements decreasing between C-6 and C-5 and seven out of eight decreasing between C-5 and C-3. (Arsenic has been omitted because of extremely low concentrations).

In the sediment, concentrations of the trace elements also decrease with distance downstream for five of the nine elements (arsenic included). This behavior is different from the other series, where increases in the trace element concentration in sediment occurred as a result of precipitation. Iron values typically decreased between C-6 and C-5, then increased again at C-3. Mean values for iron are obscured by the presence of exceptionally large concentrations of iron in the sediment at sites C-6 and C-5 at two or three times during the sampling program. The three elements whose concentrations in the sediment increased downstream are cadmium, cobalt and copper. No explanation for the difference in behavior between these three and the other five is obvious. Overall, the decreasing values in sediment suggest either dilution by sediments with lower concentrations of trace elements or dissolution of the trace elements from the sediment. Dissolution is not supported by the water analyses, however, because they also decrease downstream and the pH of the water is too high to effectively dissolve the trace elements.

Sites C-1 and C-2--

Farther downstream, the previously discussed stream joins Pond Creek, but a simple continuation of the downstream trends is unlikely because of the small size of the unnamed stream with respect to Pond Creek. When the downstream trends in the two sites on Pond Creek are examined, the elements can be seen to show a variety of behaviors. Cobalt, nickel and zinc concentrations increase in sediment and decrease in water. This would suggest that precipitation is taking these three elements out of solution. Both water and sediment have increasing concentrations of cadmium, chromium and iron downstream. Manganese decreases in concentration in both water and sediment, and copper decreases in sediment while increasing in water. Such a variety of behavior undoubtedly reflects the much more complicated stream pattern in this area, with a variety of streams discharging variable and unknown amounts of indeterminant quality water and sediment into the stream. Table 12 summarizes the downstream behavior of the two C-series segments and compares them with the H-series.

TABLE 12. CONCENTRATION VS. DISTANCE DOWNSTREAM: C-SERIES AND H-SERIES

Location	Water Decrease Seds. Increase	Both Decrease	Water Increase Seds. Decrease	Both Increase
C-6 to C-5	Cd, Co	Cr, Mn, Ni, Zn	Fe	Cu
C-2 to C-1	Co, Ni, Zn	Mn	Cu	Cd, Cr, Fe
H-series	Cd, Co, Cr, Cu, Fe, Mn, Ni	As, Zn		

Confluence of an Acidic and a Normal Stream, Site C-4

In the C-series, site C-4 is located below the confluence of a high pH site (C-8) and one with low pH (C-7). Site C-4 is not as well situated to examine mixing zone behavior as was site H-8 because it is located several kilometers downstream from the actual confluence of the contributing streams. However, because site C-7 in Bear Creek is the only one in this series that has a low pH, it is worth examining the mixing behavior in this area as well.

The major difference between this site and the previously examined H and S series is that the pH of the water resulting from mixing is near normal, with values typically about 6 or 7. This could be the result of longer downstream flow before measurement, which could allow neutralization reactions with materials in the stream bed, or neutralization by a somewhat basic groundwater. More likely, however, is the neutralization by Lake Creek. Although measurements are not available, Lake Creek (C-8) in all likelihood has a much greater discharge than Bear Creek (C-7) (surmised from basin areas), which should weaken the influence of the waters of Bear Creek on the mixed water at C-4.

Compared to Lake Creek, the low pH waters of Bear Creek contribute a greater amount of every trace element except manganese. At C-4, the resultant mean water values are lower than either contributing stream for the elements cadmium, cobalt, chromium, copper and manganese. This suggests that these elements are precipitating out of solution.

In the sediment, all elements except arsenic, nickel and zinc have lower values in low pH waters of Bear Creek than in Lake Creek. After the two streams mix, the mean concentrations in the sediment are greater than either contributing stream for all elements except iron, chromium and manganese. This general behavior suggests precipitation, with the trace elements being removed from the aqueous environment and becoming incorporated in the stream sediment. Thus once again we see an example of the trace element load of a stream being transferred from one type of geochemical environment to another in response to changes in pH.

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APPENDIX A
Concentrations of Trace Elements in Regional Stream Sediment Samples (ppm)

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
B-1	0.217	7.57	2.90	1946.84	682.78	5.20	9.97
B-2	0.187	13.20	5.10	4003.92	1422.62	8.90	16.70
B-3	0.123	10.87	3.77	5181.70	1088.20	4.57	9.23
B-4	0.127	7.77	5.03	5181.70	1038.43	5.90	10.83
B-5	0.313	14.77	5.63	3527.97	1845.79	14.97	24.47
B-6	0.133	9.23	4.90	6246.54	1141.79	6.27	11.90
B-7	0.247	4.13	6.50	5657.64	629.53	6.10	19.27
B-8	0.247	7.53	5.57	4189.46	789.61	5.83	15.50
B-9	0.350	7.20	4.77	2350.19	654.24	8.43	13.40
B-10	0.953	13.87	8.00	7053.23	1507.88	14.03	27.50
B-11	0.233	6.87	5.60	5254.30	786.13	5.13	14.60
B-12	0.273	7.63	5.27	5695.30	1201.99	4.60	8.83
B-13	0.100	3.17	4.60	4775.66	810.84	5.37	10.10
B-14	0.137	7.43	6.00	6026.05	714.79	10.00	19.40
B-15	0.183	7.90	3.33	5695.30	977.88	5.67	11.03
B-16	0.077	2.53	5.27	5878.14	416.21	5.97	13.83
B-17	0.140	8.03	6.37	4555.16	1515.19	8.53	19.53
B-18	0.103	8.50	5.47	8634.37	778.82	4.93	14.10
B-19	0.207	3.40	5.20	4151.80	430.48	6.47	14.00
B-20	0.283	9.17	4.83	6429.39	1244.80	8.87	7.50
B-21	0.120	8.63	4.20	4409.95	821.63	6.57	8.50
B-22	0.130	6.40	4.33	3159.57	768.38	5.13	11.40
B-23	0.077	5.50	3.17	3821.07	501.47	4.30	10.17
B-24	0.143	11.00	6.27	3710.82	1002.94	6.87	11.30
B-25	0.090	5.63	6.43	3159.57	455.18	4.63	9.50
B-26	0.157	8.97	3.83	4003.92	1038.43	4.57	10.63
B-27	0.220	7.37	5.50	2387.83	658.07	5.83	9.03
B-28	0.213	8.90	6.17	1984.48	718.27	5.17	9.90
B-29	0.137	6.93	4.77	4334.66	1201.99	5.93	10.77
B-30	0.133	9.53	6.50	3600.57	640.32	7.27	10.43
B-31	0.173	9.83	5.93	6026.05	704.35	6.23	12.60
B-32	0.190	17.10	9.73	5326.91	1860.06	5.17	11.63
B-33	0.133	8.57	5.43	2645.97	821.63	3.47	7.10
B-34	0.173	4.17	5.67	3710.82	401.94	6.53	45.37
B-35	0.237	7.63	9.67	9037.71	725.58	8.50	26.10
B-36	0.070	6.07	4.30	5216.66	1255.58	5.70	9.70
B-37	0.110	4.70	5.27	4262.05	942.38	6.83	16.17
B-38	0.200	9.07	4.43	3968.96	1387.13	6.90	16.43
B-39	0.130	9.47	4.20	3417.72	1056.18	7.13	7.93
B-40	0.077	6.40	4.37	2167.33	341.39	5.97	10.43
B-41	0.180	7.03	3.93	3049.32	1195.03	7.13	9.27
B-42	0.247	8.37	5.10	4885.91	2180.22	10.33	12.57
B-43	0.127	2.70	5.07	3269.82	871.39	4.90	7.70
B-44	0.173	11.67	5.70	3968.96	2283.23	8.83	11.50
B-45	0.063	3.13	4.33	3159.57	1066.97	6.83	11.57
B-46	0.313	14.37	7.60	3821.07	3055.09	16.40	17.80
B-47	0.197	9.53	5.10	1616.09	1017.20	10.13	11.90
B-48	0.083	3.03	5.23	3638.22	554.71	4.63	11.83
B-49	0.247	3.07	6.10	3380.07	754.12	12.60	21.93
B-50	0.117	3.87	5.93	2901.43	718.27	5.40	23.50
B-51	0.150	4.43	6.10	2901.43	1073.93	5.87	36.67
B-52	0.147	4.77	14.77	2129.69	298.58	6.73	11.27
B-53	0.160	9.83	2.97	2315.23	1002.94	18.73	8.17
B-54	0.047	5.00	5.40	1140.14	522.70	5.03	7.57
B-55	0.067	7.87	3.47	2204.98	629.53	5.73	10.27
B-56	0.063	7.40	3.60	2828.83	1372.86	5.03	9.53
B-57	0.110	8.37	3.53	4003.92	1298.04	5.80	8.70
B-58	0.077	4.80	2.97	1874.23	1024.16	3.10	6.67
B-59	0.130	8.23	3.90	2866.47	1241.32	8.33	14.80
B-60	0.163	9.47	3.87	2828.83	1490.14	5.73	9.07
B-61	0.097	12.67	4.23	2570.68	1995.08	6.10	8.33
B-62	0.120	6.53	4.47	3452.67	1419.14	6.47	19.60
B-63	0.187	6.87	3.37	2535.73	1564.96	7.40	7.07
B-64	0.157	4.33	4.73	1836.59	401.94	3.13	14.20
B-65	0.367	2.90	8.43	5216.66	547.75	5.57	55.00
B-66	0.153	5.87	5.80	3159.57	921.16	5.60	21.43
B-67	0.113	7.60	3.37	2019.44	739.85	6.60	10.70
B-68	0.090	1.07	3.23	1984.48	330.60	3.57	7.67
B-70	0.150	5.07	3.60	2718.58	1013.72	6.17	8.30
B-71	0.080	3.17	3.40	2828.83	1031.47	4.77	7.50
B-72	0.160	7.50	4.70	3197.22	1536.42	6.03	7.50
B-73	0.057	4.60	2.93	1175.09	704.35	2.90	5.90
B-74	0.070	5.17	2.70	2645.97	1148.75	4.33	6.40
B-75	0.113	9.83	3.20	2535.73	1173.80	3.73	5.47
B-76	0.087	6.53	3.40	1360.63	757.60	4.20	6.97
B-77	0.137	9.73	3.00	2866.47	1493.62	6.53	8.03
B-78	0.107	4.77	3.27	1470.88	448.22	3.40	6.63
B-79	0.157	9.60	3.47	2680.93	1333.54	7.73	8.33
B-80	0.143	7.47	4.77	2828.83	1596.97	8.47	12.13
B-81	0.157	5.37	3.70	2019.44	458.66	4.33	8.13
B-82	0.197	2.10	3.30	3710.82	96.05	2.40	13.57
B-83	0.150	5.30	3.13	1801.63	682.78	5.37	7.20
B-84	0.117	6.10	3.83	2976.72	658.07	4.70	7.77
B-85	0.063	3.37	2.37	699.14	238.38	3.53	7.57
B-86	0.173	5.07	2.83	1909.19	764.56	4.63	5.73
B-87	0.160	7.93	4.27	1395.59	938.90	5.57	8.53
B-88	0.077	12.23	4.50	2901.43	1436.89	8.40	9.03
B-89	0.110	4.47	2.97	844.35	472.93	2.57	5.20
B-90	0.117	5.87	3.43	1212.74	789.61	8.00	8.30
B-91	0.053	7.70	3.00	2791.18	924.64	5.07	5.30
B-92	0.050	3.03	3.93	1505.84	341.39	6.87	11.20
B-93	0.080	6.17	3.30	1836.59	554.71	6.30	12.03
B-94	0.187	6.43	4.30	2277.58	853.64	5.63	32.10
B-95	0.260	4.67	4.23	2498.08	508.43	5.67	15.87
B-97	0.087	4.17	3.37	1874.23	544.27	3.97	8.00
B-98	0.093	5.80	2.73	1470.88	686.26	3.70	7.90
B-99	0.093	3.20	3.70	1505.84	192.10	3.50	7.53
B-100	0.210	3.27	3.80	1691.38	373.40	4.63	7.80
B-101	0.083	11.47	4.00	2791.18	1646.74	5.80	8.57
B-102	0.193	7.77	5.10	5437.16	629.53	6.50	14.13
B-103	0.043	4.87	3.40	2756.22	633.01	4.00	7.77
B-104	0.040	5.53	4.20	3490.32	1020.68	4.87	8.37
B-105	0.063	8.37	3.27	2019.44	832.07	4.20	7.37
B-106	0.103	6.63	4.40	2167.33	540.44	6.23	10.70
B-107	0.093	7.73	3.37	2094.73	878.35	5.57	8.27
B-108	0.120	10.57	3.93	2277.58	1319.62	4.43	8.63
B-109	0.290	14.73	5.00	2387.83	2390.06	7.90	11.30
B-110	0.127	11.63	3.57	3232.18	1685.71	6.60	13.30
B-111	0.160	16.03	4.03	3342.43	1810.30	7.30	13.40
B-112	0.150	5.93	3.33	2019.44	1892.08	5.60	7.97
B-113	0.243	6.10	4.00	2535.73	1251.76	10.87	15.60
B-114	0.167	5.30	2.57	2498.08	1266.02	5.47	9.37
B-116	0.213	8.13	3.83	2645.97	1468.91	6.73	9.57
B-117	0.110	6.00	3.57	2460.43	1422.62	5.03	7.47
B-118	0.137	7.00	2.83	2570.68	1273.33	4.63	7.83
B-119	0.240	6.03	4.10	2756.22	1920.61	5.73	11.10
B-120	0.107	6.23	3.77	3600.57	2393.54	6.40	9.20
B-121	0.127	7.17	4.00	4444.91	714.79	3.53	7.57
B-122	0.103	4.30	2.93	2756.22	1998.91	2.57	4.60
B-123	0.700	36.43	8.43	4520.20	430.48	22.17	17.50
B-124	0.583	8.43	17.73	4409.95	376.88	12.73	88.83
B-125	0.073	5.77	3.67	4299.71	362.62	3.33	4.60
B-126	0.107	4.37	4.97	3197.22	430.48	4.20	7.93
B-127	0.123	4.63	5.03	3197.22	320.16	5.13	12.47
B-128	0.217	17.80	5.87	5033.80	1821.08	9.77	20.17
B-129	0.140	4.27	4.50	3748.46	373.40	4.97	13.07
B-130	0.167	7.90	5.37	4555.16	700.52	7.07	13.60
B-131	0.200	5.97	6.23	3968.96	707.83	6.37	13.17
B-132	0.110	3.83	4.73	3380.07	295.10	4.40	9.67
B-133	0.133	3.60	4.00	1874.23	192.10	5.47	8.97
B-134	0.130	3.37	3.87	4079.21	213.32	4.13	9.07
B-135	0.223	5.77	5.93	4444.91	384.19	6.70	14.33
B-136	0.287	18.03	5.90	4923.55	1824.56	10.67	15.13
B-137	0.367	29.67	5.23	2608.33	3303.91	16.67	17.00
B-138	0.407	33.40	7.13	3968.96	2937.82	18.10	27.90
B-139	0.150	5.70	2.43	2129.69	757.60	4.50	5.97
B-140	0.507	28.30	5.70	6246.54	2745.72	24.13	32.13
B-141	0.187	5.77	5.50	4444.91	504.95	5.97	12.73
B-142	0.297	20.47	4.43	4961.20	2030.93	12.70	15.93
B-143	0.120	3.60	3.03	2129.69	714.79	4.60	6.80

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
B-144	0.443	10.10	6.63	4630.45	1081.24	10.43	24.07
B-145	0.177	9.23	4.13	3490.32	1394.09	7.23	10.73
B-146	0.390	20.13	5.20	3600.57	2294.02	13.47	14.40
B-147	0.063	1.80	1.73	1140.14	394.63	2.87	5.47
B-148	0.313	6.40	4.43	5106.41	704.35	8.57	18.07
B-149	0.340	14.30	4.23	2425.48	2258.52	8.27	29.17
B-150	0.147	5.13	5.70	4482.55	583.25	5.10	14.03
B-151	0.250	23.43	3.80	3638.22	2699.44	16.17	23.93
B-152	0.177	15.03	5.00	4224.41	1650.22	10.23	12.03
B-153	0.230	12.17	4.93	2204.98	1753.22	8.27	22.47
B-154	0.050	2.27	3.07	2387.83	252.65	2.60	6.40
B-155	0.127	4.57	2.30	1064.84	522.70	4.53	6.90
B-156	0.187	7.83	3.63	3197.22	661.55	6.70	12.50
B-157	0.160	8.00	3.80	3307.47	778.82	6.80	10.73
B-158	0.170	10.07	3.70	2756.22	2044.85	8.17	10.73
B-159	0.123	4.57	5.43	3562.92	440.92	4.93	12.07
B-160	0.077	4.67	4.17	3452.67	320.16	5.23	13.33
B-161	0.397	6.07	5.40	4409.95	704.35	14.67	27.77
B-162	0.267	7.43	5.17	2129.69	949.69	12.47	17.90
B-163	0.290	5.53	7.07	3086.97	626.05	10.70	16.60
B-164	0.133	8.50	4.93	2828.83	1479.70	6.23	11.47
B-165	0.303	2.80	2.80	293.10	309.37	3.67	4.77
B-166	0.180	7.83	5.73	3562.92	665.03	6.77	16.33
B-167	0.140	10.00	4.20	4079.21	928.12	5.43	11.47
B-168	0.093	8.40	3.23	2315.23	1315.79	3.33	9.20
B-169	0.107	5.37	2.87	2167.33	629.53	3.90	7.90
B-170	0.100	3.47	4.03	3197.22	433.96	3.83	8.67
B-171	0.320	11.30	3.13	1653.73	1821.08	9.90	12.30
B-172	0.150	10.70	4.23	6281.50	1504.40	7.00	10.80
B-173	0.130	5.07	4.43	3821.07	323.64	5.33	12.33
B-174	0.153	12.73	4.20	4703.05	1244.80	7.97	13.83
B-175	0.140	6.53	4.63	4079.21	522.70	6.00	12.73
B-176	0.143	5.80	7.80	5474.80	401.94	5.67	14.97
B-177	0.200	9.60	4.57	4299.71	764.56	6.17	12.07
B-178	0.360	11.93	8.93	4444.91	1458.12	14.20	23.40
B-179	0.283	9.77	6.93	5695.30	995.98	10.80	36.47
B-180	0.157	5.80	4.67	3490.32	444.40	6.37	17.80
B-181	0.137	6.73	2.23	2608.33	615.26	6.57	6.60
B-182	0.393	5.23	0.80	1250.38	5402.35	7.07	13.33
B-183	0.153	8.93	4.60	2866.47	1195.03	8.43	10.97
B-184	0.220	6.77	5.13	4189.46	1259.06	8.87	12.57
B-185	0.123	3.77	3.23	3673.17	366.44	3.80	11.10
B-186	0.150	7.87	5.07	4041.57	725.58	5.00	14.27
B-187	0.260	7.03	5.53	4630.45	458.66	12.27	17.63
B-188	0.210	3.20	4.47	7383.98	167.04	3.97	23.83
B-189	0.130	4.63	4.13	6098.64	618.74	3.43	8.90
B-190	0.227	5.60	5.63	4189.46	522.70	8.40	17.73
B-191	0.347	7.07	10.60	4334.66	775.34	11.03	31.70
B-192	0.320	7.50	8.10	3232.18	914.20	11.20	21.20
B-193	0.500	4.23	8.83	3197.22	142.33	7.03	61.63
B-194	0.850	18.20	10.53	7163.48	1041.91	15.23	117.07
B-195	0.587	6.77	9.23	3710.82	337.91	7.33	79.23
B-196	0.627	3.10	1.30	919.64	234.90	3.47	26.37
B-197	0.417	14.00	7.03	3821.07	1013.72	11.50	61.50
B-198	0.353	7.83	6.57	5216.66	693.56	7.03	54.43
B-199	0.460	3.63	8.27	4262.05	192.10	5.47	69.60
B-200	0.310	9.47	5.33	1616.09	1092.02	9.07	13.50
B-201	0.090	4.20	4.43	2057.08	437.44	4.73	11.70
B-202	0.240	7.37	7.50	3638.22	700.52	7.47	14.20
B-203	0.243	5.87	5.93	2976.72	597.52	7.77	17.47
B-204	0.313	7.40	5.77	1250.38	1209.30	9.87	11.20
B-205	0.190	3.80	4.90	1946.84	519.22	6.13	22.93
B-206	0.370	7.13	7.00	3232.18	682.78	9.07	20.83
B-207	0.120	11.57	3.93	2425.48	1024.16	6.30	11.23
B-208	0.543	6.30	8.33	992.24	2454.10	23.03	19.30
D-1	0.740	22.60	5.43	6466.55	567.43	12.70	30.60
D-2	0.250	14.50	3.53	1664.66	921.44	8.40	15.20
D-3	0.170	6.70	3.70	1771.37	660.81	8.20	10.90
D-4	0.080	12.20	1.80	1675.33	687.67	3.30	4.20
D-5	0.340	18.40	4.80	3574.74	1789.47	13.00	12.00
D-6	0.240	29.70	40.29	3692.12	2568.45	16.60	15.20
D-7	0.060	8.10	3.70	2507.66	573.31	15.90	14.90
D-8	0.110	3.40	2.87	2102.16	381.18	2.90	5.20
D-9	0.0	4.50	3.67	3766.82	241.41	3.10	6.30
D-10	0.0	8.00	5.20	2529.00	684.57	6.40	37.70

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
D-11	0.270	8.90	5.17	2689.06	1291.15	8.60	11.40
D-12	0.240	12.30	5.20	2763.76	1351.99	8.60	12.20
D-13	0.320	5.30	3.50	1707.34	354.32	4.00	13.40
D-14	0.630	9.20	5.20	9443.73	902.53	9.50	18.80
D-15	0.310	21.00	3.93	2625.04	1785.23	12.80	13.90
D-16	0.030	6.40	3.10	1878.08	375.70	3.50	5.70
D-17	0.240	13.40	5.50	3094.56	1394.65	9.80	15.90
D-18	0.210	7.40	3.43	5772.95	558.13	5.50	8.40
D-19	0.790	8.60	7.54	6157.10	571.97	9.00	25.90
D-20	0.030	2.50	1.90	4460.43	111.87	2.60	6.20
D-21	1.510	12.60	4.70	7373.58	98.13	24.40	69.90
D-22	0.460	14.50	5.00	5186.05	711.74	10.90	21.50
D-23	0.150	18.30	2.83	3436.02	1326.37	10.50	18.40
D-24	0.060	13.00	2.53	2561.01	1277.30	8.10	8.60
D-25	0.160	18.60	3.20	5058.00	1539.79	17.50	26.30
D-26	0.240	4.40	3.57	1963.44	137.39	9.10	18.10
D-27	0.210	4.20	4.80	2304.91	374.98	3.70	14.30
D-28	0.080	12.90	2.57	1867.41	903.87	8.40	10.90
D-29	0.080	3.00	3.17	2443.63	305.04	4.30	5.60
D-30	0.080	3.90	4.07	3382.67	299.26	4.50	9.60
D-31	0.020	9.90	2.97	2614.37	933.83	3.90	8.80
D-32	0.220	12.10	3.97	5431.48	1255.92	5.20	25.20
D-33	0.050	1.70	4.53	2006.13	80.88	2.10	7.50
D-34	0.0	0.30	3.40	8568.72	92.66	1.40	7.30
D-35	0.040	4.60	2.10	5186.05	341.61	1.80	7.10
D-36	0.990	5.30	9.61	7821.76	407.00	11.70	131.70
D-37	0.180	2.40	3.27	16539.87	106.71	5.90	31.50
D-38	0.160	11.70	3.30	6519.91	592.94	6.60	13.20
D-39	1.050	27.40	4.40	6306.49	1039.20	49.70	96.10
D-40	0.300	3.50	3.80	7949.81	168.38	5.30	26.00
D-41	0.060	7.80	3.20	2390.28	531.99	6.00	7.10
D-42	0.310	18.10	3.93	2561.01	1782.03	9.70	9.60
D-43	0.050	8.50	4.40	2432.96	729.61	2.90	6.60
D-44	1.920	29.30	5.17	2891.81	2030.67	32.80	51.40
D-45	1.670	18.50	4.86	3190.59	1273.07	17.30	38.40
D-46	0.430	10.50	4.67	3126.57	865.96	6.50	11.40
D-47	1.440	16.80	4.13	9230.32	1071.94	14.50	39.00
D-48	1.640	26.60	4.30	2795.77	1629.45	32.20	56.30
D-49	1.440	5.30	3.82	2731.75	193.89	19.60	73.70
D-50	0.910	30.20	4.30	4236.34	2008.31	20.00	47.10
D-51	0.180	8.00	2.83	2571.68	754.81	3.90	11.30
D-52	0.060	6.80	2.37	3969.57	1213.26	4.40	10.00
D-53	0.570	11.70	4.57	4182.98	752.75	15.80	20.70
D-54	0.150	11.00	2.87	2379.61	1401.06	7.10	9.70
D-55	1.100	24.50	5.17	2507.66	2464.94	37.40	43.50
D-56	0.120	4.40	3.77	11503.21	292.34	2.30	11.90
D-57	0.090	2.40	2.70	4364.39	160.42	3.80	12.30
D-58	0.110	19.20	2.93	2070.15	1326.37	14.90	12.80
D-59	0.140	15.20	2.63	2187.53	1266.66	13.70	8.40
D-60	0.320	15.60	4.67	6167.77	687.67	11.20	23.00
D-61	0.640	2.70	1.27	971.05	287.48	3.20	3.30
D-62	0.110	4.40	2.97	1952.77	249.68	3.10	26.50
D-63	0.050	1.00	2.10	2411.62	70.97	3.20	9.90
D-64	0.140	9.60	3.20	2550.34	820.20	5.20	10.70
D-65	1.750	2.70	25.83	9433.06	97.83	7.80	36.50
D-66	0.110	8.20	4.33	3841.52	600.48	4.60	10.60
D-67	0.290	14.90	3.80	3393.34	1992.24	10.10	22.10
D-68	0.290	2.50	5.30	6103.75	173.54	5.00	12.50
D-69	0.280	19.00	11.67	8397.98	900.47	14.20	34.30
D-70	0.170	6.10	4.67	6562.59	252.77	5.00	21.40
D-71	0.0	6.80	3.33	4972.63	370.12	3.70	10.80
D-72	0.040	4.30	3.20	2646.38	439.75	6.40	7.70
D-73	0.030	2.40	2.40	3307.97	233.46	2.90	6.40
D-74	0.330	15.10	4.30	5164.71	1557.97	8.20	24.00
D-75	0.340	26.40	3.82	14213.62	11505.55	10.70	36.80
D-76	0.050	9.00	2.53	5079.34	1465.10	5.40	11.10
D-77	0.060	9.90	3.80	6391.86	946.23	5.50	8.60
D-78	0.150	7.80	2.38	7522.97	503.07	5.40	14.80
D-79	0.060	9.00	3.50	3745.48	715.87	5.50	8.50
D-80	2.040	6.50	1.76	4247.01	280.98	8.20	49.10
D-81	5.780	6.30	5.17	4940.62	329.53	9.30	96.00
D-82	0.100	3.80	3.73	1493.92	348.12	4.20	11.70
D-83	0.090	6.30	2.03	2091.49	383.97	3.50	7.10
D-84	0.070	4.40	3.03	3265.29	101.23	4.00	11.40
D-85	0.110	3.70	2.53	2091.49	263.72	3.90	9.30

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
D-86	0.110	4.80	2.23	2326.25	380.14	3.60	12.20
D-87	0.240	2.90	5.00	1835.39	107.43	3.40	12.10
D-88	0.180	4.00	4.47	1536.61	297.19	5.70	12.10
D-89	0.070	3.20	3.03	1984.79	107.43	3.80	7.30
D-90	0.060	7.50	3.57	2753.09	573.00	1.90	7.70
D-91	0.160	13.70	3.43	2272.90	1504.56	8.10	15.40
D-92	0.030	5.30	2.47	2529.00	693.45	2.60	7.10
D-93	0.0	8.10	1.83	2198.20	664.22	3.80	6.00
D-94	0.090	6.80	3.70	2507.66	400.49	4.50	9.60
D-95	0.020	10.50	2.80	2614.37	797.79	4.50	7.40
D-96	0.160	6.20	3.67	1771.37	656.99	3.60	9.40
D-97	0.030	3.40	2.67	1600.63	229.33	4.50	12.50
D-98	0.030	4.70	1.10	1664.66	422.81	3.00	7.30
D-99	0.040	2.80	2.17	2187.53	266.20	5.00	10.70
D-100	0.0	2.00	1.90	2105.37	196.27	2.90	6.30
D-101	0.030	6.60	2.50	2827.78	433.14	4.80	10.70
D-102	0.150	7.10	1.40	1785.24	421.77	5.90	7.10
D-103	0.140	4.10	3.57	426.84	49.89	6.40	12.60
D-104	0.070	17.60	3.20	3396.54	1063.89	5.50	8.40
D-105	0.090	7.00	1.77	2141.65	634.57	3.30	6.00
D-106	0.420	9.60	3.57	1987.99	982.69	5.80	16.00
D-107	0.070	13.80	3.27	4858.45	1297.76	5.60	8.40
D-108	0.070	4.30	2.00	2841.66	400.08	3.00	4.70
D-109	0.130	7.70	3.57	4140.30	713.49	4.90	11.50
D-110	0.420	3.40	1.33	746.96	554.00	4.30	9.60
D-111	0.140	13.80	2.63	2902.48	1376.58	5.00	8.10
D-112	0.080	4.70	2.43	2425.49	539.95	6.40	10.80
D-113	0.550	26.30	3.10	8454.54	2468.87	16.50	36.60
D-114	0.130	19.50	2.38	3670.78	1296.72	8.80	17.40
D-115	0.220	13.00	4.07	3425.35	967.92	8.30	12.60
D-116	0.140	14.70	3.10	3588.62	1384.94	9.20	12.50
D-117	0.170	15.70	3.23	4169.11	1360.46	10.00	13.20
D-118	0.020	7.50	1.90	2451.10	349.15	2.50	11.10
D-119	0.100	7.40	4.10	4591.68	959.66	4.30	11.10
D-120	0.110	5.10	3.10	2184.33	386.65	7.90	13.10
D-121	0.010	8.70	2.60	3987.71	665.97	3.60	10.10
D-122	0.070	5.90	2.80	2664.52	768.55	3.40	7.70
D-123	0.060	9.60	2.93	2824.58	1515.72	7.10	10.60
D-124	0.150	6.00	1.83	2504.46	553.38	4.20	12.20
D-125	0.050	4.40	2.23	2109.63	492.74	5.30	8.00
D-126	0.130	9.50	2.37	2390.28	865.65	5.40	7.60
D-127	0.260	12.70	3.37	3215.14	908.01	8.10	19.70
D-128	0.070	6.10	2.00	2382.81	622.59	3.80	7.80
D-129	0.070	11.80	3.67	5840.18	1003.77	6.20	14.30
D-130	0.170	11.60	3.27	2638.91	1256.13	5.40	8.80
D-131	0.460	16.10	3.57	2387.08	600.90	10.90	11.30
D-132	0.080	7.40	4.03	5524.32	745.83	4.90	12.40
D-133	0.080	9.80	1.93	2643.18	960.38	3.70	8.40
D-134	0.150	7.70	4.63	3670.78	687.67	4.00	11.60
D-135	0.120	9.90	3.80	2766.96	1079.17	5.10	10.10
D-136	0.120	5.40	3.20	2824.58	779.19	2.90	6.60
D-137	0.060	4.40	11.36	3272.76	583.33	3.00	7.20
D-138	0.090	8.10	3.60	2105.37	882.49	5.60	9.20
D-139	0.250	15.30	5.13	4115.76	834.66	6.40	13.10
D-140	0.520	2.70	2.67	583.70	519.60	4.00	3.80
D-141	0.480	6.60	8.26	2073.35	500.70	6.00	11.50
D-142	0.460	4.90	3.83	341.47	80.57	6.30	6.30
D-143	0.360	12.60	7.23	3375.20	877.33	7.70	11.70
D-144	0.320	6.60	8.26	3417.88	635.60	6.60	14.90
D-145	1.000	22.30	19.94	4559.67	1995.76	11.70	115.50
D-146	1.030	41.00	18.90	11186.29	2553.89	13.40	94.10
D-147	0.070	1.90	3.41	1891.95	53.41	2.00	6.80
D-148	0.080	5.60	10.64	5015.31	268.27	3.50	12.20
D-149	0.120	12.30	5.00	3766.82	846.75	4.50	9.50
D-150	0.030	11.70	2.87	3681.45	1062.23	4.20	6.90
D-151	0.140	6.10	3.07	2259.03	796.13	2.90	10.50
D-152	0.040	7.20	2.73	2934.49	787.46	5.00	11.10
D-153	0.110	9.10	4.20	3460.56	754.40	7.10	14.80
D-154	0.060	15.60	2.80	3048.67	1494.03	7.10	13.40
D-155	0.300	10.50	3.70	2158.72	1540.93	6.40	17.70
D-156	0.010	6.90	2.77	2361.47	416.30	2.00	6.20
D-157	0.130	11.40	2.30	2216.34	1071.94	4.60	5.30
D-158	0.150	13.10	3.10	2248.36	1381.84	15.80	20.00
D-159	0.140	7.30	2.60	1795.91	725.48	9.50	15.60
D-160	0.0	7.80	1.93	2070.15	450.08	2.10	4.10
D-161	0.0	15.50	2.80	3115.90	1254.78	6.70	10.60
D-162	0.0	7.80	3.13	2638.91	662.46	5.50	8.80
D-163	0.030	10.80	2.53	2766.96	1034.03	4.50	5.30
D-164	0.0	2.70	3.23	3948.23	169.72	3.50	9.40
D-165	0.090	7.40	3.73	3812.71	477.25	4.70	8.30
D-166	0.080	12.00	3.40	3033.73	2273.63	8.80	15.20
D-167	0.110	15.70	2.67	3396.54	1419.03	7.60	11.80
D-168	0.050	7.00	2.57	3486.18	780.22	7.40	15.10
D-169	0.090	11.00	3.37	5118.82	968.23	4.00	14.70
D-170	0.0	5.00	3.70	5324.77	264.14	3.50	13.20
D-171	0.070	8.10	4.27	10033.84	519.91	5.50	13.10
D-172	0.170	15.60	2.90	2336.92	1370.07	20.10	13.50
D-173	0.070	10.70	3.27	3144.71	1023.70	3.20	8.50
D-174	0.290	12.30	14.77	3475.51	869.06	10.30	34.50
D-175	0.190	9.40	7.54	3475.51	633.23	8.50	17.90
D-176	0.180	5.40	4.67	3166.05	545.11	4.30	18.10
D-177	0.170	5.00	4.10	24145.02	400.08	5.30	13.50
D-178	2.050	17.00	10.02	3449.90	1465.52	26.30	74.80
D-179	0.380	42.70	7.95	3684.65	189.76	68.00	90.50
D-180	1.180	9.60	8.99	2475.65	630.44	19.60	59.70
D-181	0.100	11.60	7.54	2649.58	1694.12	5.20	15.20
D-182	0.100	7.60	4.30	2696.53	533.34	6.50	17.70
D-183	0.010	9.50	3.60	3763.62	887.35	3.10	8.90
D-184	1.020	5.60	8.26	5594.74	119.52	11.20	144.40
D-185	0.060	2.50	4.73	3464.83	227.57	4.60	12.70
D-186	0.410	12.70	3.73	4954.49	1100.14	14.30	6[illegible].10
D-187	0.170	8.40	3.47	4172.31	492.43	9.00	[illegible]
D-188	0.090	2.30	4.40	3201.27	177.37	3.00	10.10
D-189	0.610	8.20	6.92	3734.81	443.47	20.00	30.30
D-190	0.380	23.30	4.44	4538.32	1722.73	20.10	16.80
D-191	0.500	22.30	4.40	736.29	16.84	22.10	16.80
D-192	0.120	4.70	2.90	1806.58	503.38	3.80	7.40
D-193	0.210	9.20	3.41	2308.11	818.86	10.20	12.80
D-194	0.570	9.50	11.67	4073.08	608.44	12.40	79.70
D-196	1.310	26.20	9.30	5353.58	740.66	33.20	121.00
D-197	1.580	5.30	8.99	6242.46	367.75	8.70	88.90
M-1	0.830	17.38	4.67	2521.00	2206.00	17.40	172.60
M-2	0.963	7.23	9.77	3015.00	639.90	12.60	144.60
M-3	0.313	10.90	8.17	2117.00	238.80	12.90	21.60
M-4	0.600	19.96	6.13	6573.00	1366.00	12.90	40.90
M-5	1.400	25.20	10.26	7939.00	3756.00	63.00	125.10
M-6	2.333	10.06	8.46	9070.00	662.00	30.20	135.20
M-7	0.400	20.00	5.70	7374.00	2860.00	24.10	89.80
M-8	2.500	9.96	9.10	14080.00	662.00	43.70	161.50
M-9	0.667	44.63	9.33	7171.00	5335.00	70.70	145.00
M-10	5.433	34.93	10.70	9177.00	4802.00	77.00	331.10
M-11	1.007	27.76	6.90	2943.00	2540.00	37.70	113.40
M-12	0.500	13.06	10.20	16113.00	5762.00	21.80	102.00
M-13	0.203	5.56	2.70	1061.00	821.30	2.70	44.40
M-14	1.060	4.96	5.67	2291.00	272.20	6.80	77.00
M-15	0.800	3.16	5.30	7000.00	608.00	11.40	34.00
M-16	2.023	7.13	16.80	4000.00	292.80	13.10	146.60
M-17	0.323	2.80	2.67	3124.00	113.50	5.60	16.60
M-18	4.400	26.90	8.00	6808.00	4268.00	69.70	261.70
M-19	0.730	15.30	3.00	2424.00	1108.00	6.50	35.70
M-20	0.300	9.03	2.6[illegible]	6392.00	1814.00	7.30	27.00
M-21	0.153	5.83	1.47	820.10	477.50	2.30	5.40
M-22	0.207	7.86	2.70	950.00	935.90	4.60	7.60
M-23	0.233	7.46	3.93	3649.00	1441.00	7.30	17.70
M-24	0.140	6.50	1.93	1658.00	725.80	3.20	5.80
M-25	1.933	24.56	4.26	5890.00	2593.00	11.40	31.20
M-26	0.150	6.06	1.77	669.30	668.50	5.10	7.30
M-27	0.200	5.03	2.90	2721.00	1014.00	4.20	12.50
M-28	0.200	7.50	2.20	3970.00	1110.00	6.20	14.60
M-29	0.210	6.96	4.37	1707.00	725.80	5.40	7.50
M-30	0.060	8.13	1.83	976.90	792.70	4.70	4.40
M-31	1.400	10.50	6.36	4791.00	982.00	8.30	60.30
M-32	0.167	6.53	2.16	2774.00	928.00	10.40	12.50
M-33	0.300	30.20	4.90	4770.00	3436.00	22.90	21.80
M-34	0.433	22.96	9.40	4215.00	2444.00	31.20	27.00
M-35	0.107	11.93	3.53	2448.00	1404.00	6.80	15.40
M-36	0.493	7.30	9.17	1948.00	1394.00	8.20	39.00
M-37	0.200	5.13	9.76	3575.00	662.00	14.60	25.00
M-38	0.400	18.30	6.30	4268.00	2038.00	39.50	22.90
M-39	0.233	14.33	4.40	4076.00	15.37	13.00	15.60

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
M-40	0.200	9.36	3.46	4204.00	1078.00	8.40	12.50
M-41	0.400	18.33	4.36	7896.00	1867.00	13.30	17.70
M-42	0.300	4.06	3.43	3169.00	395.00	3.30	11.40
M-43	0.200	4.10	4.56	3308.00	555.00	4.70	13.50
M-44	0.400	12.10	9.92	3201.00	18.78	8.10	37.00
M-45	0.100	5.83	3.90	1532.00	983.70	4.50	13.30
M-46	0.477	4.36	4.03	355.80	659.00	4.40	26.00
M-47	0.500	15.23	6.53	4268.00	1227.00	15.20	37.00
M-48	0.500	11.90	9.16	4066.00	790.00	10.70	46.00
M-49	0.800	44.83	9.76	5186.00	4941.00	22.20	22.00
M-50	0.200	4.70	4.10	16130.00	662.00	4.50	12.00
M-51	0.400	11.96	4.53	9775.00	2070.00	4.50	12.00
M-52	0.400	7.13	2.70	2081.00	2038.00	2.60	9.00
M-53	0.267	5.93	4.16	3799.00	566.00	3.50	14.00
M-54	0.210	21.66	3.20	2714.00	2044.00	7.20	11.30
M-55	0.100	16.10	6.03	7278.00	1409.00	7.80	16.00
M-56	0.193	4.30	3.97	1207.00	515.70	4.50	11.60
M-58	0.070	1.80	2.63	1233.00	238.70	1.00	3.90
M-59	0.287	2.76	1.43	6960.00	291.50	2.30	4.50
M-60	0.123	4.13	3.07	3302.00	448.90	3.10	5.80
M-61	0.037	4.03	3.57	2542.00	754.50	3.30	6.60
M-62	0.300	18.30	4.63	3692.00	2262.00	9.10	13.70
M-64	0.057	5.33	2.97	2233.00	472.80	3.40	14.60
M-65	0.240	28.00	6.07	3883.00	2401.00	13.60	12.80
M-66	0.373	14.30	3.30	2239.00	1411.00	9.10	9.60
M-67	0.140	14.53	2.50	2288.00	1190.00	6.70	10.10
M-69	0.173	7.93	20.47	1890.00	779.20	3.10	24.40
M-70	0.247	10.46	3.00	2037.00	1169.00	4.40	8.70
M-71	0.193	12.16	4.13	2656.00	1190.00	4.30	14.20
M-72	0.157	10.00	3.07	3110.00	1211.00	6.10	10.80
M-73	0.100	10.23	3.46	4140.00	982.00	5.30	14.00
M-74	0.187	8.86	3.30	2791.00	958.20	2.90	6.50
M-75	0.200	20.63	5.33	4983.00	1505.00	10.30	18.00
M-76	1.113	5.20	16.97	3301.00	431.70	7.10	93.60
M-77	0.467	5.26	3.63	2344.00	261.10	6.60	22.90
M-78	0.090	9.90	3.03	2129.00	926.60	4.60	11.00
M-79	0.467	5.40	5.70	2817.00	523.00	6.80	30.50
M-80	0.113	8.36	2.97	2080.00	968.80	3.70	37.20
M-82	0.313	6.43	6.30	3552.00	318.00	5.50	33.10
M-83	0.067	3.86	2.70	2166.00	448.00	3.70	11.00
M-84	0.700	7.83	5.17	3417.00	389.60	7.10	34.00
M-85	0.100	4.96	4.63	3617.00	267.00	4.20	1.90
M-87	0.033	3.20	2.60	1564.00	204.30	1.70	5.90
M-88	0.163	3.43	4.83	5779.00	169.50	3.40	10.80
M-91	0.407	4.16	7.77	3853.00	90.60	6.40	49.60
M-92	0.497	9.03	7.30	2859.00	1232.00	7.00	46.30
M-93	0.193	8.86	2.60	2037.00	1300.00	4.30	7.30
M-94	1.430	4.60	6.27	3448.00	681.70	3.20	13.90
M-96	0.400	29.13	6.33	7043.00	2337.00	8.80	16.30
M-97	0.550	6.23	6.07	3221.00	261.10	7.20	62.40
M-100	0.197	15.10	3.43	3779.00	1715.00	8.40	16.90
M-102	0.400	3.40	4.13	1926.00	1704.00	2.60	26.10
M-103	0.427	14.13	3.47	2583.00	1843.00	5.40	9.30
M-104	0.737	3.43	2.63	346.00	617.80	1.30	89.40
M-105	0.283	21.43	4.73	5331.00	1971.00	7.80	33.10
M-106	0.223	9.76	2.90	2356.00	1023.00	4.50	7.60
M-107	0.197	5.73	3.07	1577.00	788.20	1.20	10.60
M-108	0.097	9.50	3.80	1736.00	628.50	3.00	6.10
M-109	0.373	8.06	3.57	2828.00	198.00	7.10	17.20
M-110	0.170	3.73	2.27	1233.00	331.70	3.20	6.50
R-2	0.167	5.63	2.93	1910.00	1729.00	4.50	8.90
R-4	0.230	0.81	3.83	1348.00	873.40	5.70	30.60
R-7	0.267	10.46	4.03	4855.00	1643.00	6.10	12.40
R-8	0.233	11.43	4.30	5549.00	1526.00	7.40	20.50
R-9	0.200	10.50	4.43	4034.00	832.00	6.80	11.10
R-10	0.100	5.03	2.90	3127.00	1014.00	4.50	10.00
R-11	0.067	8.40	2.93	5047.00	651.00	2.50	3.80
R-12	0.133	7.63	2.66	3521.00	2454.00	10.10	14.10
R-13	0.073	1.00	8.33	7902.00	63.90	3.50	12.20
R-14	0.323	17.66	3.13	4189.00	1398.00	7.30	7.30
R-15	0.333	23.56	4.90	4941.00	2924.00	10.30	7.90
R-16	0.490	2.46	3.60	1887.00	360.30	2.70	7.80
R-17	0.033	8.66	3.33	3201.00	960.00	6.90	10.30
R-18	0.557	7.10	3.93	4314.00	589.60	6.50	8.00
R-20	0.200	0.96	3.00	4140.00	779.00	6.80	11.20

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
R-21	0.100	4.50	5.16	3799.00	1014.00	4.30	12.10
R-22	0.400	7.86	3.20	3489.00	352.00	8.80	43.20
R-23	0.320	2.50	4.23	1618.00	524.10	2.60	12.60
R-24	0.370	1.17	5.37	290.00	107.10	1.90	0.90
R-25	0.056	3.43	4.07	1721.00	535.00	4.50	9.50
R-26	0.183	2.16	9.20	2395.00	138.00	5.70	47.20
R-27	0.167	5.43	3.23	2849.00	384.00	5.30	36.50
R-28	0.120	4.36	5.17	2064.00	698.80	5.50	11.70
R-29	0.200	7.10	5.26	3991.00	181.00	8.00	34.40
R-30	0.130	2.56	1.47	176.00	545.90	3.40	3.70
R-31	0.257	2.36	1.43	280.00	393.00	2.10	2.90
R-32	0.733	7.60	3.83	1524.00	1277.00	5.80	37.20
R-33	0.200	3.16	4.63	5528.00	534.00	5.80	23.70
R-34	0.740	10.83	5.20	1867.00	768.00	5.30	24.50
R-36	0.453	6.20	2.30	2883.00	535.00	3.30	8.20
R-38	0.233	6.80	2.13	1313.00	1451.00	5.80	8.20
R-39	0.553	2.86	2.47	1400.00	360.30	2.70	5.40
R-40	0.100	6.00	6.26	5976.00	7683.00	6.60	17.30
R-41	0.300	7.83	3.10	2081.00	640.00	5.00	6.90
R-42	0.570	2.26	0.93	1110.00	300.80	0.60	4.10
R-43	0.167	7.10	4.60	4546.00	1814.00	5.00	7.70
R-44	0.210	9.73	3.17	3007.00	1081.00	4.20	8.10
R-45	0.073	4.60	3.83	2147.00	709.70	2.90	8.40
R-46	0.500	5.73	4.10	438.00	896.00	5.20	26.00
R-47	0.170	12.46	3.17	2281.00	1125.00	6.60	8.10
R-48	0.267	6.06	2.86	2486.00	512.00	4.40	11.80
R-49	0.300	12.10	1.93	3137.00	843.00	5.40	6.20
R-50	0.443	12.86	12.80	2997.00	906.20	5.90	28.10
R-51	0.410	3.33	3.53	1784.00	458.60	4.60	5.30
R-52	0.637	4.36	4.23	2530.00	285.30	6.10	29.00
R-53	0.400	4.26	3.60	2390.00	758.00	5.50	13.00
R-54	0.817	2.36	3.13	1276.00	393.50	2.50	19.80
R-55	0.700	45.26	5.50	6648.00	6242.00	28.60	42.50
R-56	0.400	5.43	4.96	3351.00	459.00	8.80	24.10
R-57	0.001	5.96	4.23	2113.00	576.00	8.60	14.60
R-59	0.001	3.96	3.83	1088.00	523.00	7.00	5.50
R-60	0.333	5.83	6.30	2273.00	384.00	10.70	22.20
R-61	0.300	4.86	5.50	3692.00	694.00	8.10	21.80
R-62	0.156	4.66	4.50	2935.00	373.90	3.20	9.10
R-63	0.100	14.76	4.26	5229.00	1056.00	7.20	11.60
R-64	0.270	4.40	2.67	2043.00	505.70	2.80	9.90
R-65	0.200	8.60	3.26	4578.00	1622.00	5.10	5.80
R-66	0.080	7.30	2.97	1825.00	545.90	2.50	10.30
R-67	0.300	4.00	1.30	587.00	1216.00	4.90	3.80
R-69	0.157	8.73	3.23	1182.00	1201.00	6.60	7.80
R-70	0.001	4.30	3.90	1597.00	436.70	1.80	6.50
R-71	0.400	25.73	5.36	6691.00	3361.00	19.10	32.70
R-72	0.400	15.53	3.20	4599.00	2198.00	9.90	13.60
R-73	0.167	4.46	3.86	2625.00	1366.00	3.00	13.80
R-76	0.107	7.13	4.30	2541.00	836.30	4.60	44.80
R-77	0.067	11.70	3.77	3049.00	1965.00	5.60	10.20
R-78	0.533	22.93	4.50	5346.00	2476.00	16.10	13.80
R-79	0.133	5.20	3.10	3063.00	544.00	2.70	11.20
R-80	0.667	6.40	2.10	892.00	1048.00	6.60	8.20
R-82	0.527	12.73	1.70	2489.00	2074.00	9.80	12.90
R-83	0.343	10.13	4.90	3640.00	895.30	6.50	9.10
R-86	0.167	11.36	4.46	2806.00	2422.00	10.20	16.70
R-88	0.333	4.13	3.33	1379.00	360.30	1.30	5.40
R-89	0.867	10.20	3.90	1338.00	1342.00	6.90	8.50
R-90	0.797	6.46	4.33	1369.00	1136.00	6.20	13.60
R-91	0.160	6.50	3.47	1835.00	1747.00	7.80	15.90
R-92	0.367	18.13	4.03	2593.00	2113.00	8.50	11.90
R-93	0.073	12.76	3.33	1763.00	1954.00	9.10	7.50
R-95	0.100	5.46	4.20	4642.00	619.00	4.00	10.30
R-96	0.687	6.26	9.07	5683.00	393.00	10.60	71.80
R-97	0.002	2.86	2.27	1649.00	524.10	2.90	5.00
R-98	0.133	24.76	4.43	5997.00	2252.00	5.20	17.10
R-99	0.100	2.50	4.00	2540.00	331.00	1.60	11.50
R-100	0.377	19.00	4.13	2489.00	2631.00	13.00	12.90
R-101	0.133	4.66	2.50	1985.00	459.00	1.70	7.10
R-102	0.100	7.60	3.20	2316.00	939.00	5.40	7.40
R-103	0.267	6.83	2.88	4631.00	1120.00	4.70	10.60
R-104	0.120	3.23	2.07	1213.00	469.50	3.80	4.40
R-105	0.140	2.46	1.33	871.00	502.20	4.40	3.90
R-106	0.170	3.96	2.27	1130.00	458.60	5.40	7.00

Sample	Cd	Co	Cu	Fe	Mn	Ni	Zn
R-107	0.467	9.83	2.43	944.00	164.90	11.40	8.20
R-108	0.390	3.76	3.43	1950.00	862.50	5.70	6.50
R-109	0.133	9.30	3.40	3041.00	726.00	7.40	13.80
R-110	0.300	22.76	5.22	4226.00	2689.00	12.70	18.40
R-111	0.143	5.30	2.40	6539.00	548.30	4.20	5.90
R-112	0.001	4.20	2.80	2540.00	523.00	3.20	8.40
R-113	0.150	4.13	4.03	1544.00	553.90	4.40	7.00
R-114	0.113	12.70	2.20	2291.00	1051.00	8.00	8.00
R-115	0.117	3.33	2.77	730.60	544.40	3.50	9.00
R-116	0.510	16.50	3.33	4143.00	1394.00	1.30	11.00
R-117	0.001	8.63	4.26	3692.00	1035.00	6.90	12.30
R-118	0.363	3.77	4.50	724.20	423.10	3.80	7.10
R-119	0.267	8.43	5.76	3959.00	715.00	6.50	15.10
R-120	0.133	3.53	4.60	3553.00	523.00	3.00	9.70
L-2	0.480	3.03	4.17	3135.00	193.80	3.60	6.90
L-3	0.293	12.30	3.17	1258.00	1534.00	6.10	7.10
L-4	0.163	12.40	3.17	2975.00	948.00	7.20	5.70
L-5	0.197	12.60	2.87	1650.00	1779.00	4.10	8.40
L-6	0.060	3.60	2.80	1221.00	214.80	2.10	5.50
L-7	0.167	8.06	4.40	3313.00	382.20	3.30	7.60
L-8	0.100	8.80	3.00	3415.00	715.00	3.20	16.10
L-9	0.130	3.06	3.50	2724.00	145.30	3.20	7.90
L-10	0.083	4.30	4.10	2491.00	285.40	3.00	5.70
L-11	0.120	4.66	4.63	2325.00	256.90	3.20	6.20
L-12	0.070	3.43	5.70	1399.00	173.70	3.00	5.70
L-14	0.073	5.53	2.87	1644.00	788.20	3.60	5.50
L-15	0.100	7.36	4.10	2221.00	777.60	5.50	9.60
L-16	0.063	5.63	3.43	2086.00	894.80	4.60	5.80
L-17	0.090	10.30	3.83	2178.00	937.40	4.90	8.60
L-18	0.120	5.86	3.07	2098.00	681.70	3.50	6.10
L-19	0.137	3.16	3.87	2399.00	340.90	3.60	7.20
L-20	0.120	5.46	2.13	1104.00	841.50	3.10	5.70
L-21	0.170	17.80	5.27	4314.00	2120.00	6.00	5.70
L-22	0.257	9.20	3.53	6379.00	5265.00	7.00	14.70
L-23	0.110	5.70	4.03	3325.00	831.90	3.10	7.90
L-24	0.230	12.03	2.37	1646.00	1601.00	6.50	10.30
L-25	0.080	10.46	3.63	3989.00	863.50	4.90	8.10
L-26	0.267	4.93	5.00	3895.00	683.00	4.10	14.30
L-27	0.197	3.20	21.37	2503.00	431.70	2.40	42.00
L-28	0.127	5.63	4.07	2858.00	1127.00	3.80	7.40
L-29	0.097	4.46	3.67	2749.00	239.00	3.10	6.80
L-30	0.163	6.00	2.93	2147.00	589.70	4.10	5.90
L-31	0.333	5.70	2.70	995.00	695.00	4.80	4.70
L-32	0.053	4.43	2.13	745.40	537.00	3.00	2.90
L-33	0.263	7.90	4.97	4910.00	1369.00	6.20	11.70
L-34	0.147	4.16	3.33	1442.00	684.50	2.70	4.30
L-35	0.200	9.23	3.33	2188.00	704.00	3.10	11.90
L-36	0.107	10.26	3.50	2302.00	884.50	1.20	9.20
L-37	0.170	4.26	2.97	2099.00	494.90	3.20	5.60
L-38	0.093	2.26	3.40	1666.00	274.80	1.90	5.10
L-39	0.090	2.90	3.47	2005.00	342.20	1.80	3.70
L-40	0.173	6.06	4.40	1808.00	979.30	4.30	7.90
L-41	0.090	10.10	3.93	2293.00	834.00	4.10	6.50
L-42	0.067	2.80	3.53	2448.00	219.00	2.80	5.90
L-43	0.177	2.96	6.83	3672.00	366.00	3.70	14.20
L-44	0.120	13.06	3.80	2672.00	1424.00	8.80	11.70
L-45	0.150	7.16	3.60	1672.00	4577.00	10.10	16.20
L-46	0.083	16.10	3.00	2103.00	1658.00	5.20	8.50
L-47	0.080	6.70	3.03	1370.00	1332.00	3.80	3.80
L-48	0.187	4.70	4.90	1810.00	793.00	3.80	7.50
L-49	0.190	3.73	7.60	3732.00	325.00	4.20	14.20
L-50	0.260	4.56	5.27	4086.00	1322.00	5.70	20.40
L-51	0.253	5.46	3.87	2345.00	529.00	4.40	10.80
L-52	0.217	3.50	7.50	2552.00	219.00	2.80	29.60
L-53	0.497	7.33	1.09	2257.00	240.00	8.20	73.80
L-54	0.643	13.36	8.03	3465.00	732.00	13.00	83.20
L-55	0.400	1.00	0.90	341.00	1024.00	4.10	3.30
L-56	0.463	2.50	1.97	212.00	356.00	3.50	2.50
L-57	0.207	9.96	2.10	5000.00	1698.00	9.50	72.80
L-58	0.150	2.86	5.23	2991.00	346.00	2.70	15.80
L-59	0.123	3.10	5.60	1948.00	407.00	2.90	11.50
L-60	0.103	3.46	4.40	2552.00	427.00	3.10	10.50
L-62	0.127	6.30	4.27	1836.00	651.00	4.40	9.10
L-64	0.530	7.62	4.20	3735.00	629.00	12.20	24.40
L-65	0.250	6.40	5.00	5181.00	722.00	9.50	21.30
L-66	0.737	12.06	10.67	4336.00	3926.00	14.10	73.80
L-67	0.350	5.23	4.17	2310.00	1210.00	6.30	14.00
L-68	0.310	6.60	7.43	3396.00	793.00	8.70	38.80
L-71	0.217	6.36	5.80	3060.00	1220.00	7.40	19.30
E-1	0.200	7.56	3.03	2422.00	1007.00	5.70	15.60
E-2	0.167	5.83	4.06	5730.00	576.00	4.30	8.60
E-3	0.133	5.16	3.70	5186.00	950.00	4.60	11.20
E-5	0.100	8.10	5.10	6317.00	373.00	12.20	28.20
E-6	0.433	19.63	6.13	4407.00	2774.00	11.00	18.00
E-7	0.133	5.36	4.26	5997.00	704.00	4.30	9.60
E-9	1.933	57.97	6.46	5890.00	4151.00	5.30	159.40
E-10	1.600	12.73	6.96	5357.00	630.00	16.60	87.60
E-11	0.923	8.66	6.83	4215.00	864.00	9.90	40.60
E-12	0.300	5.46	4.63	4151.00	566.00	6.70	28.90
E-13	0.700	16.90	7.76	9294.00	1377.00	19.50	75.10
E-14	0.100	4.96	4.03	6146.00	736.00	4.00	8.50
E-15	0.733	5.23	7.23	9284.00	459.00	10.30	29.10
E-16	0.100	5.13	5.06	4012.00	619.00	4.50	26.00
E-17	0.400	13.53	8.10	7587.00	1953.00	8.20	23.70
E-18	2.700	9.53	7.00	10671.00	277.00	13.30	104.00
E-19	0.233	2.50	4.10	8142.00	587.00	4.40	14.20
E-20	0.200	28.60	4.80	7576.00	3212.00	10.60	11.60

APPENDIX B

Detailed Study of Three Streams; Concentrations of Trace Elements in Sediment (ppm)

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
2-15	H-1	-	0.70	0.237	0.97	5.50	14.07	3748	16.87	2.10	16.60
	H-2	-	0.80	0.167	0.63	4.40	8.90	3535	17.67	2.33	23.33
	H-31	-	0.80	0.103	0.83	2.77	2.37	2774	15.80	1.47	13.37
	H-32	-	0.70	0.147	0.50	5.00	2.83	4193	23.03	1.97	17.60
	H-4	-	0.40	0.227	0.72	7.65	2.74	6857	29.10	1.87	8.92
	H-5	-	0.60	0.123	0.50	6.80	1.27	6408	16.43	1.37	6.70
	H-6	-	0.07	0.207	6.80	3.83	16.17	5547	499.00	5.30	13.23
	H-7	-	0.60	0.057	1.30	7.43	10.70	6099	62.30	1.80	14.37
	H-8	-	0.50	0.060	1.60	5.27	7.10	4530	87.80	1.83	14.10
2-19	H-1	-	0.50	0.253	0.70	4.23	24.06	2546	22.37	2.00	24.67
	H-2	-	0.60	0.117	1.06	5.73	7.43	3948	55.80	2.63	33.93
	H-31	-	0.80	0.117	0.47	5.40	13.50	4044	13.53	1.87	17.10
	H-32	-	0.60	0.107	0.13	3.93	14.90	3175	8.97	1.60	11.57
	H-5	-	0.35	0.210	0.37	9.17	33.47	6992	39.80	1.70	13.50
	H-6	-	0.08	0.170	6.60	4.77	18.43	2695	455.90	4.93	11.47
3-5	H-1	-	0.60	0.177	1.07	4.93	3.10	3713	36.37	1.47	17.83
	H-2	-	0.75	0.203	0.87	3.03	6.00	2759	68.20	1.87	20.77
	H-31	-	0.65	0.117	0.30	3.67	17.03	2991	11.63	1.57	19.00
	H-32	-	0.80	0.140	0.53	4.70	3.17	3823	17.93	0.67	11.47
	H-4	-	0.40	0.073	0.67	3.67	1.47	3133	14.50	1.50	4.00
	H-5	-	0.10	0.167	1.32	6.01	3.66	5192	47.19	3.21	6.96
	H-6	-	0.40	0.123	3.17	2.83	21.17	1756	256.30	2.57	6.87
	H-7	-	0.30	0.057	1.23	4.53	1.80	3468	68.20	1.70	5.03
	H-8	-	0.10	0.083	2.63	3.53	1.87	2510	200.60	3.13	5.30
3-19	H-1	2.94	0.70	0.233	1.60	5.60	2.80	3724	36.90	4.23	45.70
	H-2	2.83	0.80	0.153	1.10	5.50	4.97	3802	30.53	2.97	21.30
	H-31	2.81	0.80	0.113	0.43	4.33	28.40	3894	32.00	1.87	34.87
	H-32	2.80	0.80	0.120	0.60	5.03	1.90	3798	10.60	0.87	10.80
	H-4	2.78	0.70	0.127	0.47	10.47	39.40	9508	15.97	4.30	17.50
	H-5	2.79	0.90	0.043	0.87	14.63	17.20	14770	39.30	3.40	18.20
	H-6	7.35	0.10	0.083	2.80	2.63	0.73	1540	191.50	1.40	2.20
	H-7	2.79	0.50	0.073	0.66	5.97	1.27	4528	39.20	0.83	4.57
	H-8	3.09	0.15	0.137	2.40	4.83	1.57	3767	240.20	1.47	4.77
3-24	S-1	6.95	0.30	0.890	6.63	5.60	11.56	2397	519.90	3.40	22.00
	S-2	6.74	0.60	0.327	2.97	6.53	7.27	5147	235.10	3.27	11.50
	S-3	4.43	0.60	1.143	0.80	14.40	23.87	7790	65.10	2.90	26.33
4-2	H-1	2.95	0.70	0.197	1.77	5.77	4.27	4087	34.80	2.10	29.66
	H-2	2.61	0.70	0.163	1.13	5.77	2.93	4098	20.33	1.27	17.37
	H-31	2.57	0.70	0.073	1.83	3.70	5.07	3852	17.15	3.67	12.63
	H-32	2.72	0.70	0.023	0.53	5.17	2.20	3621	20.27	0.93	11.20
	H-4	2.79	0.50	0.077	0.70	5.87	1.70	4424	14.53	0.97	5.90
	H-5	2.79	0.60	0.013	0.50	4.67	11.80	4300	29.50	0.97	8.37
	H-6	7.36	0.10	0.133	2.83	2.53	0.97	1294	165.40	1.33	4.03
	H-8	3.93	0.07	0.090	1.90	1.60	0.90	1230	105.90	0.90	2.40
4-7	S-1	7.21	0.30	0.900	4.03	4.20	3.50	2706	262.30	3.17	19.33
	S-2	6.90	0.50	0.177	3.90	2.87	5.80	2518	233.80	2.63	9.13
	S-3	3.09	0.70	1.133	1.80	9.77	7.50	3933	52.70	2.80	12.33
	S-4	2.64	0.70	0.203	4.63	5.13	7.90	5385	75.40	6.97	12.43
	S-5	3.67	0.07	0.453	8.10	9.97	40.03	6050	387.60	5.23	21.97
4-9	C-1	7.24	0.60	1.483	10.63	6.02	14.60	6104	594.00	16.60	144.60
	C-2	6.85	0.60	1.050	9.17	4.43	11.90	4360	2554.00	10.57	83.67
	C-3	7.19	0.20	0.993	5.67	6.27	4.13	3955	280.20	16.07	72.40
	C-4	7.23	0.30	0.900	11.07	3.77	14.87	2930	1298.00	19.37	73.53
	C-5	7.49	0.15	1.070	6.10	3.77	3.47	2444	421.00	11.17	67.40
	C-6	7.25	0.10	1.203	7.17	3.70	4.43	2564	80.40	11.43	80.57
	C-7	4.50	0.09	0.690	5.87	5.50	5.10	4083	55.50	16.53	64.97
	C-8	7.09	0.09	0.724	14.54	1.01	53.14	9033	3002.00	15.42	56.14
4-16	H-1	3.04	0.80	0.377	1.80	6.83	8.73	5250	62.60	4.83	70.00
	H-2	2.89	0.70	0.257	0.83	6.33	4.57	5752	18.73	1.70	20.80
	H-31	2.84	0.80	0.197	0.63	3.70	2.73	3596	8.90	0.87	11.20
	H-32	2.72	0.60	0.200	0.93	4.10	3.13	3173	16.30	0.93	11.70
	H-4	2.77	0.30	0.028	1.43	9.36	2.98	6808	40.40	1.03	9.53
	H-5	2.77	0.30	0.030	0.43	4.50	19.60	4012	45.50	1.70	10.50
	H-6	6.66	0.20	0.077	3.20	1.60	14.80	1828	279.20	2.57	6.97
	H-7	2.73	0.40	0.082	0.93	6.20	1.20	4680	26.87	0.83	5.13
	H-8	3.12	0.20	0.040	1.53	3.67	0.90	1835	89.30	0.87	3.90
4-21	S-1	6.95	0.20	1.033	6.73	2.43	11.67	2095	602.20	3.80	23.33
	S-2	6.93	0.50	0.200	1.80	3.70	14.90	2973	157.60	3.53	11.76
	S-3	3.06	0.70	1.070	1.57	14.67	26.67	8661	64.40	3.53	32.87
	S-4	2.74	0.04	0.100	1.80	3.97	4.60	4080	78.80	3.20	7.73
	S-5	3.61	0.70	0.477	4.10	6.53	14.00	3767	502.90	4.23	111.90
4-23	C-1	7.50	0.70	1.410	6.67	10.17	28.30	6086	328.10	14.27	161.10
	C-3	7.32	0.60	1.560	7.43	4.07	10.20	3677	630.70	20.30	100.80
	C-4	7.08	0.08	0.327	9.27	4.77	4.70	2447	1339.00	25.49	40.10
	C-5	-	0.40	1.770	6.43	6.60	17.13	4435	333.50	10.00	127.40
	C-6	7.30	0.20	3.427	17.63	3.37	9.27	4037	3827.00	26.27	257.50
	C-7	5.98	0.40	0.203	2.57	3.13	2.93	1892	39.80	6.20	21.47
	C-8	6.93	0.03	0.253	7.73	6.27	36.90	4258	958.00	8.73	28.93
4-30	H-1	2.60	0.70	0.240	1.50	6.03	17.27	5648	40.93	3.73	38.73
	H-2	2.89	0.85	0.110	0.87	9.63	16.90	6811	20.83	2.40	24.13
	H-31	2.84	0.80	0.077	0.57	7.23	2.73	6064	12.43	1.73	18.40
	H-32	2.74	0.70	0.133	0.70	8.00	3.70	6164	27.97	1.87	17.23
	H-4	2.82	0.70	0.140	0.51	6.85	1.63	5592	14.93	1.49	10.61
	H-5	2.78	0.70	0.133	0.60	8.40	2.23	7295	22.93	1.57	10.80
	H-6	7.30	0.07	0.197	3.67	1.90	12.32	2543	364.60	1.43	40.33
	H-7	2.83	0.70	0.090	0.27	5.30	0.77	4471	17.17	1.43	3.03
	H-8	3.33	0.50	0.108	2.29	6.57	1.80	5250	179.30	2.29	10.47
5-4	S-1	6.43	0.60	0.887	4.23	2.10	10.03	2888	414.20	2.93	10.61
	S-2	5.28	0.60	0.327	5.40	3.33	25.60	3816	226.60	4.90	21.83
	S-3	5.98	0.40	0.963	2.06	8.40	14.00	4634	71.30	2.90	17.23
	S-5	5.60	0.09	0.435	5.47	10.53	47.57	9541	274.70	5.12	25.40
5-8	C-1	5.98	0.40	1.487	11.87	7.50	16.20	7214	582.30	18.83	139.50
	C-2	6.29	0.50	0.874	16.89	8.39	61.15	9489	236.90	18.90	115.60
	C-3	6.43	0.40	1.530	9.43	3.33	11.77	3479	785.10	23.67	117.10
	C-4	6.55	0.40	0.823	15.87	5.43	33.77	4178	1621.00	21.40	80.04
	C-5	6.39	0.50	0.697	4.53	2.57	5.43	2500	514.70	8.83	90.20
	C-6	6.52	0.50	4.123	21.77	4.20	13.33	3372	2625.00	30.43	305.80
	C-7	3.61	0.10	0.160	1.33	6.13	4.80	5752	72.30	40.33	30.80
	C-8	6.31	0.08	0.724	14.27	12.10	34.20	10950	6755.00	16.67	76.20

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
5-13	H-1	2.44	0.70	0.057	1.23	9.33	9.43	9223	74.40	2.67	35.10
	H-2	2.30	0.70	0.016	1.03	6.33	8.73	6203	50.60	2.20	24.57
	H-31	2.21	0.70	0.027	1.10	7.47	15.03	7598	34.80	2.53	32.20
	H-32	2.23	0.80	0.073	1.03	7.23	12.60	8223	32.60	1.70	22.13
	H-4	2.35	0.80	0.185	0.42	13.72	24.80	7629	63.80	3.85	13.67
	H-5	2.36	0.80	0.292	2.33	18.16	24.20	18920	67.20	4.37	16.80
	H-6	5.92	0.09	0.120	2.85	1.97	8.87	1572	257.60	2.72	6.02
	H-7	2.44	0.80	0.116	0.86	6.19	10.20	6528	48.50	1.91	6.87
	H-8	3.14	0.60	0.086	1.32	3.40	7.08	3219	96.70	1.02	3.20
6-4	S-1	7.34	0.35	1.351	7.65	2.55	8.57	2252	796.50	3.32	30.27
	S-2	6.32	0.50	0.430	5.23	4.10	6.03	3560	246.20	2.93	17.93
	S-3	2.61	0.10	1.257	3.50	17.30	18.37	12900	188.60	8.53	79.75
	S-4	2.31	0.40	0.177	1.93	20.17	3.27	41400	72.90	6.10	12.70
	S-5	2.69	0.60	0.580	6.30	9.47	7.43	8377	117.00	5.30	51.10
	C-1	6.35	0.09	1.507	4.70	4.10	8.40	2913	302.70	6.20	87.23
	C-2	6.72	0.60	0.160	1.53	3.93	9.10	3105	170.30	3.73	12.87
	C-3	6.79	0.40	1.383	10.50	5.20	14.10	4034	889.40	25.00	118.80
	C-4	6.73	0.40	0.878	20.53	5.23	23.34	4361	1760.00	37.01	114.00
	C-5	6.30	0.30	3.913	21.57	4.97	10.90	4123	2176.00	38.90	256.50
	C-6	7.19	0.09	6.153	27.77	4.03	9.50	3849	3159.00	52.37	411.10
	C-7	7.04	0.50	0.670	7.72	6.27	12.42	5554	372.40	9.70	47.25
	C-8	-	0.20	0.157	2.77	4.56	5.47	5506	578.10	2.47	9.70
	H-1	2.59	0.80	0.355	2.28	6.95	16.70	5803	49.78	4.88	80.78
	H-2	2.70	0.70	0.190	1.90	7.50	5.70	9700	91.20	4.96	30.90
	H-31	2.65	0.50	0.124	1.60	11.03	7.63	21400	33.30	3.55	38.20
	H-32	2.62	0.50	0.060	0.90	11.00	3.00	1800	21.26	3.00	22.47
	H-4	2.63	0.80	0.039	0.47	18.16	1.10	36160	18.79	4.05	14.73
	H-5	2.62	0.70	0.022	5.34	11.12	22.76	108400	64.00	10.70	32.57
	H-6	6.92	0.10	0.057	5.35	2.13	27.41	4189	477.90	1.95	11.38
	H-7	2.61	0.50	0.000	0.72	9.30	0.90	10540	11.10	1.90	5.40
	H-8	2.79	0.50	0.047	4.40	6.00	12.75	18880	98.13	1.10	16.48
6-18	S-1	7.09	0.20	0.380	3.70	7.63	4.40	5979	473.70	3.83	14.83
	S-2	7.00	0.40	0.283	2.70	2.03	4.23	1903	146.70	2.23	7.43
	S-3	2.80	0.30	0.910	4.23	17.97	9.50	31120	201.10	8.47	35.47
	S-4	2.67	0.09	0.137	2.13	8.80	6.20	17490	98.80	3.93	10.73
	S-5	3.28	0.09	0.330	3.67	5.13	6.13	4966	159.80	2.27	14.90
	C-1	7.53	0.40	0.757	5.10	3.20	11.50	3066	523.70	7.47	53.26
	C-2	7.33	0.50	0.550	5.23	2.97	10.17	2945	463.10	7.60	32.10
	C-3	6.69	0.20	5.343	12.33	11.57	14.63	9913	580.50	42.10	307.10
	C-4	7.68	0.20	0.540	10.60	4.20	23.07	2725	500.00	24.97	6.93
	C-5	7.31	0.40	2.267	10.17	8.67	7.20	7043	762.50	24.20	103.30
	C-6	7.62	0.20	4.780	22.23	4.40	7.03	4151	3248.00	39.33	189.90
	C-7	3.28	0.25	0.687	5.73	7.00	4.90	6050	245.90	12.27	40.97
	C-8	7.29	0.08	0.590	8.20	15.10	7.60	15830	4234.00	31.20	38.60
	H-1	2.75	0.50	0.223	1.03	5.43	4.00	5122	125.30	2.77	31.97
	H-2	2.85	0.60	0.127	0.90	5.83	4.96	4777	16.80	1.20	22.50
	H-31	2.77	0.70	0.100	1.06	7.73	4.46	9422	17.77	2.20	26.56
	H-32	2.73	0.80	0.077	1.03	10.33	2.63	19210	39.37	3.43	28.13
	H-4	2.70	0.60	0.150	1.63	10.40	4.27	11050	61.60	2.57	13.10
	H-5	2.68	0.50	0.286	3.00	15.10	6.67	18900	88.70	5.38	18.10
	H-6	7.82	0.10	0.040	1.57	1.03	5.20	3557	137.39	1.03	3.80
	H-7	2.67	0.60	0.000	0.58	8.67	1.15	8210	31.25	1.99	10.31
	H-8	2.76	0.30	0.080	0.67	3.57	1.70	4144	34.40	0.40	3.63
7-3	S-1	6.80	0.50	0.903	4.47	4.67	3.63	3688	498.10	4.07	24.87
	S-2	6.60	0.50	0.537	2.53	4.17	3.50	3052	149.60	3.53	15.43
	S-3	2.63	0.20	0.793	2.60	31.00	7.17	26900	160.10	8.00	19.07
	S-4	2.43	0.02	0.250	2.23	13.93	2.13	10050	122.70	4.80	12.97
	S-5	2.97	0.50	0.467	2.63	15.90	3.23	16870	80.40	4.53	13.00
7-3	C-1	6.54	0.40	0.905	6.96	13.50	10.05	6712	637.50	13.92	72.89
	C-2	6.92	0.40	0.640	3.53	8.20	9.20	4848	332.00	5.97	23.60
	C-3	7.15	0.20	1.917	8.87	12.40	5.80	6950	401.50	30.70	96.20
	C-4	7.18	0.90	0.777	17.67	7.93	7.83	5566	1295.00	24.43	66.97
	C-5	7.37	0.25	4.200	21.83	7.93	7.50	45860	268.30	52.07	293.70
	C-6	7.20	0.50	4.090	18.23	8.37	8.60	60410	238.90	36.00	289.90
	C-7	3.20	0.40	1.100	4.43	2.63	5.07	2077	172.20	8.90	83.70
	C-8	6.85	0.07	0.527	7.64	12.87	5.27	9913	2598.00	24.11	35.44
	H-1	2.29	0.70	0.457	2.57	17.07	5.37	19950	54.20	6.70	89.90
	H-2	2.67	0.80	0.160	1.27	9.37	2.90	8062	45.33	3.53	36.70
	H-31	2.58	0.80	0.123	1.30	13.47	3.33	19140	29.27	3.60	30.17
	H-32	2.53	0.70	0.113	1.10	14.25	3.13	15780	29.84	4.87	37.00
	H-4	2.59	0.70	0.097	1.57	17.53	1.40	24430	50.43	3.73	21.37
	H-5	2.47	0.80	0.091	1.36	18.44	3.26	22630	42.47	4.47	22.80
	H-6	6.57	0.10	0.018	3.21	20.11	7.39	22250	107.70	4.55	12.67
	H-7	2.36	0.80	0.074	1.31	20.12	3.01	39790	48.34	5.45	18.75
	H-8	2.62	0.09	0.063	3.10	3.90	1.10	3087	313.30	3.60	5.50
7-17	S-1	6.65	0.40	0.357	3.27	6.00	4.30	3873	366.30	3.57	11.70
	S-2	6.53	0.40	0.337	3.27	6.07	4.95	3820	152.40	4.53	17.93
	S-3	2.58	0.30	1.983	3.07	29.70	8.90	15100	124.30	10.77	39.23
	S-5	2.77	0.40	0.297	2.17	20.77	4.07	14290	51.66	4.47	11.10
	C-1	7.13	0.20	0.977	5.17	8.60	7.77	3986	286.50	11.73	69.07
	C-2	6.59	0.50	0.493	5.70	6.67	7.97	4655	122.40	9.37	40.07
	C-3	7.64	0.30	0.987	10.60	8.30	5.17	5794	114.20	36.17	108.80
	C-4	2.38	0.40	0.810	19.60	6.60	6.80	4317	1115.00	26.07	73.40
	C-5	7.50	0.25	3.347	15.93	4.90	5.57	3385	843.80	49.37	217.50
	C-6	7.08	0.09	3.387	19.43	5.47	4.67	3948	1998.00	53.36	240.28
	C-7	3.12	0.40	0.157	3.57	7.17	3.20	5143	47.13	9.67	16.66
	C-8	7.35	0.08	0.267	8.03	12.27	4.50	9898	1787.00	13.60	30.40
	H-1	-	0.60	0.340	2.13	4.77	8.37	6288	27.67	5.20	53.30
	H-2	2.59	0.50	0.110	1.50	7.00	3.27	5538	40.00	3.57	31.97
	H-31	2.55	0.60	0.087	0.77	8.57	3.93	7032	18.70	2.27	27.27
	H-32	2.48	0.50	0.053	0.87	6.30	3.07	5850	21.60	2.47	25.13
	H-4	2.38	0.60	0.037	0.70	6.90	2.30	5943	16.90	2.03	15.07
	H-5	2.33	0.50	0.117	1.03	10.30	2.30	7710	36.63	3.23	17.70
	H-6	6.48	0.15	0.217	5.83	3.70	1.87	2364	598.40	4.97	10.37
	H-7	6.87	0.30	0.053	0.43	6.03	1.43	4503	27.70	1.33	8.67
	H-8	2.18	0.40	0.055	1.29	10.58	1.58	7131	49.37	1.96	9.67
7-31	S-1	6.50	0.25	0.463	3.73	5.93	4.37	4066	303.10	3.60	14.17
	S-2	6.60	0.25	0.420	2.43	3.70	3.17	3930	301.80	2.27	8.13
	S-3	2.81	0.50	2.793	2.50	29.57	11.57	15100	85.68	6.00	18.43
	S-4	2.51	0.07	0.127	1.83	14.00	1.30	13510	91.43	4.40	9.67
	S-5	3.19	0.10	0.430	1.77	20.47	3.13	16050	55.73	4.77	7.43
	C-1	6.89	0.40	1.097	6.50	8.73	9.40	4645	534.70	13.23	81.10
	C-2	7.20	0.40	0.567	5.67	7.47	9.60	4520	326.40	10.23	55.63
	C-3	7.31	0.20	1.130	5.07	20.00	3.43	16680	235.10	21.23	82.60
	C-4	6.90	0.40	0.903	20.53	8.60	6.93	5083	934.20	28.67	9.27
	C-5	7.11	0.30	3.627	17.67	6.80	6.13	3791	1418.00	50.33	229.30
	C-6	7.30	0.09	5.483	27.20	8.40	6.47	5808	3472.00	75.40	275.00
	C-7	3.70	0.08	0.293	3.77	9.87	3.70	6573	181.10	11.67	75.70
	C-8	7.16	0.07	0.333	5.77	12.33	3.60	9002	2078.00	15.30	25.70
	H-1	2.40	0.50	0.280	1.50	4.40	6.03	3845	31.93	3.13	40.33
	H-2	2.85	0.50	0.103	0.97	5.90	3.40	4592	30.50	2.50	25.90
	H-31	2.70	0.40	0.077	0.70	5.30	2.57	3980	22.27	2.37	28.47
	H-32	2.65	0.60	0.057	0.50	4.73	2.20	3255	24.93	1.53	21.53
	H-4	2.60	0.50	0.877	22.13	8.70	6.47	5054	1207.00	27.40	82.60
	H-5	2.59	0.40	0.000	0.98	8.05	2.13	7278	25.79	1.45	16.17
	H-6	6.85	0.20	0.000	2.63	4.27	1.13	2151	221.90	2.20	5.00
	H-7	2.62	0.10	0.000	0.80	7.90	1.60	5481	43.47	1.33	10.27
	H-8	2.88	0.40	0.010	0.90	9.27	0.80	6555	44.40	1.07	4.27

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
8-16	S-1	6.82	0.40	0.983	4.20	6.17	3.07	2799	229.50	3.60	19.70
	S-2	6.42	0.30	0.703	4.60	6.30	4.53	2817	147.30	4.47	14.27
	S-3	2.71	0.20	1.773	2.40	23.73	5.80	13510	96.23	5.43	16.50
	S-4	2.40	0.02	0.220	1.93	11.50	1.43	12270	124.10	4.80	11.63
	S-5	3.17	0.40	0.420	2.20	12.13	2.87	8597	53.23	4.03	11.00
	C-1	7.03	0.40	0.880	6.43	7.03	8.03	4176	342.60	12.50	74.50
	C-2	7.33	0.40	0.400	4.50	5.57	8.30	3656	489.30	8.60	37.03
	C-3	7.53	0.08	1.630	10.40	8.90	6.30	4802	658.20	35.77	124.60
	C-4	7.50	0.25	0.930	23.00	3.43	9.80	2198	1069.00	35.30	92.67
	C-5	7.34	0.20	3.933	26.17	4.93	6.80	3421	2948.00	64.33	278.90
	C-6	7.63	0.20	5.977	35.43	7.53	6.93	5965	4696.00	83.30	403.90
	C-7	3.13	0.09	0.437	7.67	10.40	3.60	8515	337.10	15.90	56.80
	C-8	6.66	0.07	0.306	8.63	29.55	9.77	29650	2989.00	25.47	38.06
	H-2	2.72	0.50	0.050	1.10	1.50	2.57	3450	26.57	2.63	21.60
	H-31	2.58	0.50	0.020	0.60	4.60	2.60	4866	33.53	1.93	22.33
	H-32	2.48	0.50	0.000	0.70	2.83	5.00	3351	16.07	1.20	17.33
	H-4	[illegible]	0.40	0.100	0.97	10.47	4.10	7203	56.20	2.07	21.20
	H-5	2.44	0.60	0.040	0.53	10.68	4.49	7433	17.49	1.60	12.42
	H-6	7.63	0.08	0.195	3.41	4.31	3.36	1533	337.30	3.20	5.77
	H-7	2.39	0.60	0.073	0.73	5.90	3.13	4147	36.90	1.20	11.83
	H-8	2.45	0.40	0.070	0.60	12.17	2.13	11640	33.63	1.83	7.87
8-30	S-1	6.56	0.40	0.277	2.00	2.60	4.20	2105	185.00	1.47	6.57
	S-2	6.85	0.30	0.483	3.27	5.77	5.83	2927	143.10	3.57	15.23
	S-3	2.61	0.20	0.987	1.70	28.77	4.50	28690	70.77	4.67	13.33
	S-4	2.39	0.01	0.083	1.30	6.30	1.67	3613	88.90	3.57	6.80
	S-5	2.88	0.09	0.100	0.77	21.30	2.17	21780	33.27	2.80	4.13
	C-1	6.96	0.40	0.890	6.17	7.50	7.23	4154	432.10	13.80	73.10
	C-2	7.05	0.30	0.303	3.13	3.20	7.10	2752	436.90	8.27	26.77
	C-3	7.54	0.20	2.107	7.47	9.73	7.73	5257	539.40	33.83	107.40
	C-4	6.28	0.50	4.287	22.80	5.00	6.17	4066	2923.00	70.33	275.80
	C-5	7.40	0.30	5.530	30.70	12.07	9.07	1274	4327.00	100.40	29.93
	C-6	7.07	0.09	6.333	38.27	7.93	6.67	6086	6447.00	96.38	428.00
	C-7	3.14	0.09	0.383	3.80	6.70	3.20	4727	109.10	10.00	37.33
	C-8	7.57	0.06	0.167	3.30	9.47	2.87	7427	753.10	5.80	11.10
	H-2	2.75	0.50	0.113	0.67	2.80	2.57	3677	30.20	2.33	37.00
	H-31	2.57	0.60	0.093	0.10	8.60	2.20	3279	13.27	2.03	16.30
	H-32	2.54	0.60	0.107	0.20	8.97	2.63	3827	25.73	0.70	25.43
	H-4	2.49	0.50	0.083	0.90	10.30	3.37	4671	12.07	2.48	15.22
	H-5	2.50	0.60	0.185	1.11	12.37	15.43	14240	37.34	2.51	26.82
	H-6	7.36	0.08	0.200	4.73	6.90	2.30	2247	591.90	6.13	10.23
	H-7	2.46	0.60	0.067	0.40	4.40	1.97	4157	22.53	1.13	7.53
	H-8	2.72	0.40	0.037	0.50	15.27	1.20	6249	22.40	2.40	5.33
9-13	S-1	6.54	0.25	0.210	3.53	12.06	4.87	5579	526.80	3.33	10.07
	S-2	6.36	0.40	0.543	4.73	14.43	6.20	4600	218.00	6.67	17.77
	S-3	2.54	0.10	2.190	1.89	31.90	8.21	20950	93.75	6.48	15.74
	S-4	2.30	0.06	0.240	2.11	26.78	4.14	12600	98.06	4.18	13.10
	S-5	2.88	0.07	0.320	2.50	51.00	4.66	29520	61.21	4.87	10.32
	C-1	6.72	0.40	1.223	7.97	10.20	7.60	1031	478.20	12.67	7.23
	C-2	6.91	0.40	0.600	6.77	12.57	7.93	5854	491.70	11.50	42.10
	C-3	6.53	0.08	3.627	12.27	16.83	8.17	1789	528.40	46.37	21.93
	C-4	-	0.40	1.157	25.50	15.93	8.87	6526	2354.00	65.97	133.30
	C-5	6.90	0.30	2.087	10.03	17.63	7.63	7124	542.60	31.97	143.60
	C-6	6.65	0.10	7.897	46.23	19.60	8.90	8372	8807.00	125.90	460.70
	C-7	3.06	0.08	0.180	3.97	22.53	6.43	9433	95.43	11.30	21.20
	C-8	6.65	0.02	0.260	5.73	33.13	3.63	18520	2774.00	16.23	19.07
	H-2	2.59	0.60	0.033	2.03	13.90	5.37	7508	31.47	4.17	35.00
	H-31	2.51	0.50	0.153	1.37	12.13	2.50	6334	14.67	2.83	19.70
	H-32	2.51	0.60	0.080	1.20	15.80	3.70	7529	23.20	2.30	25.20
	H-4	-	0.60	0.052	1.57	23.12	5.07	12930	18.46	2.20	19.56
	H-5	-	0.50	0.125	1.48	29.84	5.86	16650	39.49	2.58	26.35
	H-6	7.00	0.10	0.260	3.77	5.40	2.80	2628	806.40	4.03	7.57
	H-7	2.36	0.40	0.010	0.47	15.63	3.67	6644	34.30	2.77	15.33
	H-8	2.72	0.20	0.000	0.50	20.03	1.10	10840	12.13	1.93	3.30
9-27	S-1	6.17	0.15	0.243	3.13	10.30	5.00	4506	514.00	3.37	10.70
	S-2	5.51	0.40	0.597	3.43	10.97	6.23	4104	183.20	5.63	14.47
	S-3	2.62	0.50	2.532	2.01	48.60	10.96	19750	82.65	6.59	19.01
	S-4	2.33	0.04	0.073	1.67	17.20	2.17	8238	98.70	3.97	7.43
	S-5	2.82	0.08	0.225	2.03	41.50	3.07	37280	58.84	6.71	5.34
	C-1	6.92	0.40	1.193	9.13	18.10	10.63	7295	62.73	22.77	105.60
	C-2	6.89	0.40	0.473	5.60	11.87	9.93	5064	437.00	9.47	36.77
	C-3	6.72	0.08	1.692	18.71	19.49	10.39	7436	4119.00	88.90	162.50
	C-4	7.24	0.10	0.907	22.53	12.23	8.00	5165	2636.00	57.33	125.60
	C-5	7.62	0.30	4.227	33.10	16.67	11.87	6221	49.97	107.90	307.80
	C-6	7.18	0.15	6.257	38.20	20.63	8.47	7732	9230.00	121.90	391.50
	C-7	3.46	0.06	0.977	11.17	23.97	10.77	9472	285.10	25.97	80.33
	C-8	6.86	0.03	0.237	5.13	29.50	4.27	14470	1426.00	7.57	13.83
10-11	S-1	7.35	0.30	1.275	3.57	8.03	4.48	3156	359.70	5.57	23.28
	S-2	6.68	0.30	0.565	2.70	10.30	6.55	3434	184.70	5.85	13.51
	S-3	3.04	0.40	2.527	1.66	49.97	13.22	15080	92.76	6.44	24.03
	S-4	2.58	0.04	0.262	1.73	24.12	2.84	12310	117.80	5.32	12.59
	S-5	3.27	0.09	0.433	1.82	39.98	5.00	20120	29.33	4.99	8.73
	C-1	7.33	0.40	1.135	8.02	18.56	11.10	6539	478.90	22.35	96.60
	C-2	7.14	0.40	0.445	5.85	12.33	8.35	4693	515.90	9.30	31.57
	C-3	7.44	0.08	2.020	11.96	26.12	9.98	8340	3032.00	78.40	136.90
	C-4	7.38	0.20	1.188	27.17	13.38	7.99	4687	2420.00	54.55	124.00
	C-5	7.00	0.50	3.843	30.40	17.32	10.63	5938	4479.00	91.33	274.80
	C-6	7.29	0.50	4.257	27.91	22.38	8.18	8636	5958.00	90.92	289.30
	C-7	3.24	0.08	0.313	4.28	20.53	5.73	7707	233.50	10.55	28.28
	C-8	6.96	0.08	0.190	4.58	39.67	3.47	19840	906.30	6.43	14.00
10-25	S-1	7.28	0.20	0.410	4.13	4.70	3.90	3253	474.40	2.30	8.57
	S-2	4.78	0.30	0.530	4.50	9.57	6.73	5319	337.60	8.07	15.90
	S-3	2.79	0.08	0.690	2.63	17.50	5.30	9973	128.80	4.90	13.37
	S-4	2.37	0.06	0.210	0.73	13.43	2.80	9113	105.10	4.10	8.33
	S-5	3.19	0.50	2.583	0.67	39.40	16.03	11240	88.60	5.40	22.17
	C-1	7.43	0.30	1.010	6.40	11.37	11.70	5424	813.90	20.07	91.40
	C-2	7.49	0.40	0.430	4.50	7.80	12.70	3942	895.60	10.30	22.60
	C-3	7.23	0.04	1.250	7.07	16.77	12.10	9630	3561.00	69.12	127.20
	C-4	7.60	0.40	1.133	23.03	9.27	9.20	4701	1986.00	43.73	117.50
	C-5	7.77	0.10	3.737	28.57	11.40	11.67	6014	4281.00	84.88	285.10
	C-6	7.82	0.07	6.057	25.60	14.70	9.47	7185	6306.00	157.70	529.50
	C-7	3.18	0.09	0.063	4.10	16.53	5.63	9000	141.00	10.13	22.77
	C-8	7.34	0.04	0.597	8.77	24.83	7.27	22300	303.50	17.07	33.23
	H-2	2.81	0.50	0.183	0.93	6.43	4.57	6574	47.30	3.30	27.33
	H-31	2.59	0.50	0.163	0.20	5.70	3.77	4319	35.53	3.30	23.80
	H-32	2.50	0.50	0.063	0.17	8.70	3.50	6154	20.50	4.00	16.77
	H-4	2.36	0.40	0.047	0.17	8.37	3.80	6360	25.40	1.17	17.50
	H-5	2.35	0.60	0.100	0.33	14.03	5.23	9401	27.67	3.33	24.20
	H-6	7.46	0.20	0.387	5.40	4.43	3.70	2363	1122.00	5.93	7.00
	H-7	2.30	0.50	0.097	0.20	6.10	2.63	4494	31.77	1.33	10.07
	H-8	2.51	0.40	0.130	0.40	15.60	1.53	10840	35.73	2.03	6.37

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
11-6	S-1	6.79	0.40	1.317	5.20	5.87	5.33	4486	615.90	5.27	31.70
	S-3	2.90	0.10	3.733	14.90	10.30	15.43	7278	109.10	23.73	95.53
	S-4	2.37	0.04	0.297	1.27	9.10	2.33	8460	87.50	5.17	8.70
	S-5	3.10	0.08	0.327	0.77	17.40	6.23	13800	49.63	4.47	7.00
	C-1	7.18	0.40	1.117	8.67	11.57	11.27	8300	666.40	27.57	183.60
	C-2	7.12	0.50	0.670	5.97	6.77	7.63	5019	724.70	11.10	51.67
	C-3	7.04	0.09	1.113	11.20	10.00	8.00	6905	1916.00	68.69	310.00
	C-4	7.08	0.30	1.457	37.63	6.37	10.06	4094	2130.00	54.43	168.00
	C-5	7.02	0.40	1.300	10.43	8.37	6.90	6387	1866.00	39.27	172.10
	C-6	7.18	0.20	2.937	16.60	5.63	6.93	41390	2718.00	44.00	172.77
	C-7	3.06	0.20	0.357	2.80	7.06	5.50	5252	89.60	9.50	30.97
	C-8	7.02	0.10	0.103	1.60	5.77	3.13	4654	384.80	6.03	7.47
	H-4	-	0.40	0.227	0.50	8.27	4.37	9560	26.97	31.70	19.03
	H-5	-	0.40	0.255	0.70	8.17	3.23	9200	41.16	95.53	14.17
	H-6	-	0.08	0.243	5.47	4.10	3.80	3086	646.90	8.70	7.40
	H-7	-	0.40	0.113	0.31	6.92	2.42	7151	31.52	7.00	12.17
11-27	S-1	7.32	0.40	0.710	3.60	4.60	4.27	2923	448.50	2.70	12.40
	S-2	7.12	0.40	0.250	5.73	3.57	4.20	2531	156.90	4.90	11.47
	S-3	4.46	0.40	1.047	1.36	25.67	10.23	21290	31.13	3.97	10.20
	S-4	2.67	0.08	0.157	2.10	5.83	4.30	5062	73.33	4.27	19.20
	S-5	4.90	0.09	0.277	2.13	27.07	3.93	26370	101.70	6.30	8.60
	C-1	6.86	0.40	0.783	11.60	7.93	8.73	5482	1287.00	16.73	62.20
	C-2	7.05	0.20	0.337	6.07	7.17	8.17	4852	766.40	10.97	39.20
	C-3	7.35	0.08	1.603	13.10	10.63	7.63	7678	1508.00	48.20	145.00
	C-4	7.51	0.20	1.790	24.43	7.17	9.63	5322	1602.00	29.27	114.00
	C-5	7.60	0.40	3.287	22.03	8.13	7.43	6252	2931.00	69.77	218.20
	C-6	7.81	0.20	1.423	11.23	4.93	5.50	3826	1508.00	25.00	109.00
	C-7	3.48	0.10	0.310	4.20	7.80	5.27	6699	35.13	12.47	26.90
	C-8	7.29	0.10	0.190	4.36	8.03	[illegible]	6870	1341.00	9.36	19.60
	H-1	4.54	0.60	0.040	0.43	5.87	10.82	6392	19.10	2.00	17.43
	H-2	3.01	0.30	0.060	0.47	4.80	3.67	4094	19.67	2.00	15.80
	H-31	2.95	0.60	0.040	0.33	7.20	5.73	6900	22.47	3.13	21.17
	H-32	3.02	0.60	0.020	0.33	5.40	4.10	5820	23.53	2.07	13.13
	H-4	3.13	0.60	0.022	0.14	9.24	2.60	10800	19.78	3.61	9.57
	H-5	3.05	0.25	0.143	0.63	6.27	4.17	5381	68.83	3.06	13.40
	H-6	7.59	0.09	0.103	2.47	2.13	2.00	1862	185.30	2.40	3.63
	H-7	3.05	0.20	0.157	0.40	6.93	2.47	6699	33.93	2.53	8.93
	H-8	3.64	0.30	0.160	0.83	7.03	2.63	6870	48.17	3.03	9.90
12-13	S-1	7.18	0.30	0.470	5.07	0.40	3.80	1267	544.30	3.50	12.97
	S-2	6.85	0.20	0.233	3.20	1.13	4.07	759	329.10	3.97	10.50
	S-3	4.84	0.40	1.823	2.10	2.40	7.73	977	25.13	3.17	12.33
	S-4	2.51	0.07	0.260	1.93	1.33	3.33	2031	97.52	5.30	9.67
	S-5	4.99	0.08	0.630	2.20	4.83	4.20	4277	142.10	6.97	12.40
	C-1	6.74	0.20	0.733	7.87	2.53	8.40	839	1348.00	16.60	83.16
	C-2	6.83	0.50	1.243	11.10	2.00	8.27	1127	1015.00	18.87	105.08
	C-3	7.03	0.50	1.967	1.37	0.90	3.53	985	159.10	40.72	5.37
	C-4	7.04	0.50	0.530	28.63	2.60	8.07	1521	1551.00	32.77	85.32
	C-5	7.28	0.30	2.607	15.63	1.50	6.80	1105	1531.00	76.25	181.10
	C-6	7.64	0.10	2.297	17.50	0.80	5.77	790	1905.00	46.07	179.30
	C-7	3.22	0.09	0.487	7.67	1.23	4.97	991	132.80	26.37	102.60
	C-8	7.03	0.07	0.517	7.87	0.70	5.33	2693	8200.00	10.43	32.67
	H-1	5.33	0.50	0.150	2.00	1.17	7.53	1799	14.17	3.23	11.53
	H-2	2.48	0.50	0.053	2.40	1.00	3.47	922	16.77	2.63	15.00
	H-31	2.75	0.40	0.180	2.27	0.23	3.50	891	16.87	3.60	15.73
	H-32	2.55	0.40	0.140	1.87	0.47	2.40	656	11.33	2.70	12.87
	H-4	2.70	0.40	0.307	2.40	1.30	2.23	73	22.73	2.97	7.80
	H-5	2.75	0.40	0.070	2.63	1.80	2.23	77	42.10	3.07	16.50
	H-6	6.96	0.30	0.117	7.53	1.10	2.76	37	828.10	6.00	7.70
	H-8	2.95	0.60	0.000	1.40	1.93	2.17	120	29.30	2.90	7.43
1-10	S-1	7.23	0.30	1.677	3.33	0.70	3.57	648	441.70	4.60	30.53
	S-2	6.86	0.30	0.203	3.63	1.03	4.00	927	231.40	4.23	12.60
	S-3	4.52	0.25	0.267	1.50	3.47	4.27	1825	41.83	1.03	8.07
	S-4	2.54	0.09	0.510	3.57	2.03	5.23	2063	96.77	7.17	21.83
	S-5	4.59	0.09	0.356	1.73	2.40	3.03	1462	86.72	1.07	11.87
	C-1	7.10	0.25	1.077	8.27	3.00	10.50	1464	653.20	19.30	191.50
	C-2	7.26	0.40	0.610	9.20	2.87	12.43	1660	816.50	12.17	52.10
	C-3	7.28	0.40	1.453	10.53	3.00	7.13	2551	1248.00	44.70	132.50
	C-4	7.38	0.20	0.693	17.60	1.00	5.23	806	1341.00	30.37	82.84
	C-6	7.35	0.08	7.613	45.03	0.97	7.07	758	9360.00	154.40	445.70
	C-7	3.35	0.30	0.777	8.07	2.20	8.50	1916	490.00	27.97	77.33
	C-8	7.24	0.08	0.913	5.97	0.03	5.90	2028	1325.00	14.53	37.63
	H-1	4.52	0.40	0.093	0.10	1.50	5.10	1780	20.00	4.83	10.80
	H-2	2.95	0.40	0.010	0.67	0.77	2.53	1353	21.47	4.80	14.33
	H-31	2.88	0.40	0.007	0.03	0.80	2.70	886	13.83	4.33	13.47
	H-32	4.50	0.40	0.000	0.80	0.57	3.47	1575	33.53	5.40	7.27
	H-4	2.95	0.50	0.053	0.00	1.47	2.37	2874	22.97	3.20	8.80
	H-5	3.02	0.40	0.210	1.17	1.87	3.63	4520	40.50	4.47	11.57
	H-7	2.92	0.40	0.100	0.13	1.03	1.60	2499	24.00	1.43	7.43
	H-8	4.54	0.40	0.190	0.73	0.50	1.07	2258	149.00	1.67	11.00
1-23	S-1	7.32	0.30	2.543	2.67	0.43	4.13	606	556.50	6.17	39.47
	S-2	7.15	0.20	0.640	4.13	1.03	6.63	1088	190.10	6.70	15.67
	S-3	4.03	0.15	1.887	4.47	2.97	10.57	2007	28.40	14.77	44.63
	S-4	2.18	0.08	0.363	2.37	1.10	3.70	2397	60.48	5.43	6.47
	S-5	4.59	0.08	0.747	2.90	3.53	4.87	2254	95.36	6.77	16.97
	C-1	6.89	0.40	0.600	9.90	1.77	7.10	1347	1236.00	14.03	43.13
	C-2	6.83	0.40	0.553	4.87	0.77	6.60	1095	633.40	9.30	35.43
	C-3	6.09	0.08	0.793	16.70	1.20	5.10	1071	1780.00	48.84	141.80
	C-4	2.47	0.20	0.287	27.37	0.77	6.13	828	1543.00	33.40	86.08
	C-5	6.56	0.08	2.833	28.70	2.40	9.70	1973	4176.00	116.60	258.40
	C-6	6.95	0.20	2.010	15.67	0.87	6.76	917	1718.00	44.73	164.20
	C-7	2.89	0.07	0.090	3.10	1.20	2.17	944	22.03	8.07	6.30
	C-8	6.58	0.08	0.327	9.63	1.87	4.60	1250	1225.00	11.93	22.37
	H-1	3.93	0.40	0.170	1.74	5.40	6.13	1660	12.53	3.10	26.33
	H-2	2.64	0.40	0.043	0.74	6.73	2.80	2161	12.37	2.70	14.07
	H-31	2.60	0.50	0.133	0.90	1.37	3.53	1094	13.97	3.00	15.63
	H-32	3.48	0.50	0.167	0.60	1.80	3.10	1257	17.13	2.77	14.37
	H-4	2.33	0.40	0.140	1.10	1.87	4.00	1490	60.60	2.67	11.03
	H-5	2.62	0.40	0.167	0.37	1.70	2.07	1782	16.47	0.77	7.60
	H-6	3.03	0.08	0.227	3.43	0.97	1.90	396	427.30	0.87	5.23
	H-7	2.57	0.60	0.267	0.63	2.03	2.93	1999	35.70	0.10	8.33
	H-8	4.23	0.50	0.263	0.80	1.73	2.03	2546	50.00	2.87	5.23
2-6	S-3	4.57	0.30	1.300	2.44	20.97	10.53	6153	39.10	6.67	18.27
	S-4	2.75	0.04	0.343	5.44	10.67	3.77	3575	73.17	9.60	10.60
	S-5	5.07	0.07	0.840	5.47	16.57	5.47	5375	455.80	7.77	26.23
	H-5	3.15	0.40	0.177	1.07	21.20	1.60	8544	22.60	5.80	8.20
2-21	S-1	7.26	0.20	1.220	5.00	1.40	4.17	596	602.20	5.53	22.83
	S-2	7.03	0.15	0.313	3.33	1.83	4.40	657	274.60	4.40	8.87
	S-3	4.72	0.30	1.340	5.17	4.83	11.47	2767	27.77	15.03	31.93
	S-4	2.71	0.03	0.203	3.67	1.77	2.80	2710	97.97	6.33	8.30
	S-5	6.17	0.07	0.350	2.90	5.07	3.70	2903	56.57	5.60	6.30
	C-3	6.72	0.20	2.570	9.03	5.00	9.70	1684	600.10	38.87	17.50
	C-4	7.17	0.20	0.767	8.87	2.27	7.37	892	1298.00	27.23	6.57
	C-5	6.83	0.20	4.017	28.23	3.10	9.00	1263	3639.00	112.30	25.03
	C-6	6.92	0.08	4.277	31.77	2.03	7.67	1288	4771.00	108.30	26.77
	C-7	6.46	0.04	0.507	6.20	1.40	3.80	1763	54.40	19.97	41.97
	C-8	6.98	0.07	0.770	7.93	1.83	5.10	3303	1543.00	14.13	40.23

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
3-6	S-1	7.43	0.30	3.157	4.87	3.97	4.80	1490	561.90	7.47	42.57
	S-2	6.94	0.20	0.633	4.27	5.63	3.83	1840	245.30	6.67	11.70
	S-3	4.65	0.30	1.313	3.41	14.63	9.33	4098	44.47	10.07	29.37
	S-4	2.62	0.04	0.163	1.64	11.73	2.43	3992	85.03	6.57	7.37
	S-5	6.36	0.08	0.620	4.71	16.17	4.90	4832	228.00	9.77	19.03
	C-1	7.13	0.30	1.083	8.17	7.33	8.07	2321	859.70	14.87	78.04
	C-2	7.17	0.40	0.760	6.84	6.67	8.57	1972	584.40	14.60	58.73
	C-3	6.91	0.08	2.413	10.74	14.13	9.53	4471	769.70	50.50	182.60
	C-4	7.14	0.20	0.613	11.01	4.50	5.50	1453	707.70	19.00	49.00
	C-5	7.37	0.40	3.740	23.47	8.50	7.57	2482	2611.00	42.88	278.30
	C-6	7.59	0.09	3.577	30.21	8.87	7.73	2840	3463.00	44.50	267.00
	C-7	3.18	0.05	0.163	1.94	11.93	2.80	4205	106.10	5.60	7.30
	C-8	5.92	0.07	0.780	7.51	19.73	4.97	8004	1696.00	17.90	33.00

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
3-20	C-2	3.15	0.30	1.270	14.07	8.00	7.83	2290	1227.00	22.37	84.40
	C-3	4.45	0.09	1.730	9.17	13.83	7.67	4352	399.60	43.13	140.50
	C-4	5.80	0.20	0.767	11.87	4.57	5.33	1563	528.10	18.60	52.07
	C-5	7.16	0.30	2.423	19.51	9.93	8.80	3073	1636.00	29.04	168.10
	C-6	7.56	0.10	0.830	6.24	6.67	4.73	1995	488.20	16.40	46.33
	C-7	3.72	0.07	0.203	1.43	12.67	3.50	4487	55.50	6.93	13.87
	C-8	7.34	0.07	0.803	11.24	13.60	4.90	5265	845.80	15.27	39.57

APPENDIX C

Detailed Study of Three Streams; Concentrations of Trace Elements in Water (ppm)

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
3-19	H-1	2.94	0.003	0.011	0.05	0.05	0.03	14.15	1.85	0.24	1.60
	H-2	2.83	0.001	0.063	0.53	0.09	0.27	50.55	13.65	1.27	20.12
	H-31	2.81	0.001	0.074	0.51	0.14	0.29	320.00	15.66	1.27	23.81
	H-32	2.80	0.000	0.021	0.24	0.03	0.10	143.30	7.79	0.26	9.20
	H-4	2.78	0.000	0.032	0.34	0.01	0.13	228.00	10.47	0.47	11.56
	H-5	2.79	0.000	0.021	0.25	0.02	0.13	166.20	8.22	0.47	8.81
	H-6	7.35	0.000	0.000	0.11	0.00	0.02	10.45	0.54	0.03	0.22
	H-7	2.79	0.000	0.032	0.30	0.07	0.22	177.00	8.51	0.54	9.16
	H-8	3.09	0.000	0.011	0.03	0.05	0.04	31.79	2.07	0.27	19.14
3-24	S-1	6.95	0.000	0.000	0.05	0.01	0.04	11.91	0.32	0.05	0.47
	S-2	6.74	0.000	0.000	0.14	0.02	0.07	10.11	0.44	0.08	0.94
	S-3	4.43	0.000	0.007	0.00	0.01	0.02	11.23	1.31	0.07	0.33
	S-5	6.12	0.000	0.000	0.01	0.04	0.04	4.49	1.37	0.06	0.33
4-2	H-1	2.95	0.001	0.003	0.01	0.06	0.01	18.31	1.23	0.01	1.41
	H-2	2.61	0.003	0.032	0.30	0.09	0.13	171.40	13.00	0.46	7.61
	H-31	2.57	0.000	0.042	0.36	0.13	0.13	65.48	10.83	0.75	9.82
	H-32	2.72	0.001	0.014	0.09	0.09	0.13	55.38	3.19	0.21	2.78
	H-4	2.79	0.001	0.042	0.07	0.00	0.07	2.25	3.04	0.12	2.50
	H-5	2.79	0.001	0.011	0.06	0.01	0.07	7.96	2.94	0.13	2.61
	H-6	7.36	0.000	0.007	0.02	0.05	0.00	0.00	0.54	0.02	0.39
	H-7	3.04	0.000	0.011	0.10	0.03	0.13	10.11	1.90	0.12	1.48
	H-8	3.93	0.000	0.011	0.08	0.03	0.08	7.67	0.65	0.01	0.44
4-7	S-1	7.21	0.000	0.004	0.08	0.31	0.03	0.33	0.87	0.06	0.33
	S-2	6.90	0.000	0.000	0.17	0.08	0.03	0.44	0.58	0.03	0.47
	S-3	3.09	0.000	0.013	0.11	0.08	0.05	25.12	5.16	0.27	0.90
	S-4	2.64	0.000	0.072	0.85	0.16	0.14	27.63	53.13	1.80	5.93
	S-5	3.67	0.000	0.001	0.12	0.09	0.05	9.14	4.63	0.08	0.83
4-9	C-1	7.24	0.000	0.000	0.00	0.03	0.06	0.45	0.54	0.01	0.47
	C-2	6.85	0.000	0.001	0.01	0.06	0.07	1.30	1.74	0.00	0.50
	C-3	7.19	0.000	0.005	0.05	0.07	0.06	0.91	0.70	0.00	0.39
	C-4	7.23	0.000	0.002	0.04	0.01	0.03	1.22	0.65	0.00	0.39
	C-5	7.49	0.000	0.006	0.00	0.38	0.02	0.00	2.68	0.06	0.58
	C-6	7.25	0.000	0.002	0.03	0.01	0.03	0.04	3.81	0.11	0.61
	C-7	4.50	0.000	0.000	0.00	0.04	0.03	1.05	3.04	0.04	0.61
	C-8	7.09	0.000	0.000	0.00	0.06	0.02	0.74	0.49	0.00	0.39
4-16	H-1	3.04	0.003	0.210	1.17	0.20	0.35	13.25	21.27	3.01	54.04
	H-2	2.89	0.001	0.053	0.45	0.05	0.22	1.31	12.28	1.06	18.71
	H-31	2.84	0.001	0.064	0.39	0.11	0.21	77.22	14.27	1.08	22.03
	H-32	2.72	0.003	0.042	0.32	0.07	0.15	274.10	11.42	0.78	15.66
	H-4	2.77	0.000	0.026	0.38	0.08	0.10	73.01	10.07	0.68	9.71
	H-5	2.77	0.002	0.021	0.30	0.06	0.08	213.80	8.37	0.60	7.61
	H-6	6.66	0.000	0.000	0.24	0.04	0.00	17.52	0.33	0.00	0.25
	H-7	2.73	0.000	0.020	0.22	0.03	0.03	68.52	66.98	0.47	3.92
	H-8	3.12	0.000	0.001	0.00	0.00	0.05	39.25	1.59	0.11	0.00
4-21	S-1	6.95	0.000	0.000	0.05	0.01	0.07	0.87	0.44	0.02	0.11
	S-2	6.93	0.000	0.000	0.00	0.02	0.09	0.00	0.87	0.04	0.33
	S-3	3.06	0.000	0.034	0.19	0.07	0.25	9.08	10.18	0.61	0.00
	S-4	2.74	0.000	0.084	1.01	0.03	0.18	8.54	65.17	1.95	4.93
	S-5	3.61	0.000	0.003	0.09	0.00	0.10	3.04	5.66	0.19	0.00
4-23	C-1	7.50	0.000	0.001	0.02	0.06	0.04	0.01	1.04	0.00	0.00
	C-2	7.30	0.000	0.000	0.00	0.00	0.08	0.32	1.88	0.17	0.00
	C-3	7.32	0.000	0.000	0.04	0.00	0.00	1.61	2.10	0.11	0.00
	C-4	7.08	0.000	0.004	0.00	0.07	0.00	1.01	1.52	0.05	0.00
	C-5	-	0.000	0.007	0.00	0.04	0.04	0.00	1.20	0.16	0.22
	C-6	7.30	0.000	0.001	0.01	0.03	0.00	0.53	1.15	0.13	0.25
	C-7	5.98	0.000	0.000	0.06	0.00	0.04	0.06	2.61	0.12	0.00
	C-8	6.93	0.000	0.000	0.00	0.00	0.00	0.01	0.76	0.07	0.14
4-30	H-1	2.60	0.003	0.098	0.42	0.87	0.75	9.92	17.18	0.98	24.42
	H-2	2.89	0.003	0.080	0.50	0.10	0.37	1692.00	15.87	1.23	24.58
	H-31	2.84	0.003	0.084	0.58	0.10	0.35	1226.00	15.98	1.31	25.04
	H-32	2.74	0.001	0.048	0.40	0.06	0.27	539.50	13.59	0.83	18.55
	H-4	2.82	0.000	0.026	0.24	0.02	0.17	145.20	10.47	0.52	10.73
	H-5	2.78	0.000	-	0.17	0.00	0.08	-	-	0.46	-
	H-6	7.30	0.000	-	0.06	0.00	0.06	-	-	0.00	-
	H-7	2.83	0.000	-	0.13	0.05	0.06	-	-	0.42	-
	H-8	3.33	0.000	-	0.01	0.03	0.04	-	-	0.16	-
5-4	S-1	6.43	0.000	0.000	0.00	0.03	0.26	0.41	0.02	0.04	0.08
	S-2	5.28	0.000	0.000	0.02	0.03	0.05	0.11	0.01	0.03	0.10
	S-3	5.98	0.000	0.000	0.03	0.04	0.06	0.00	0.78	0.07	0.06
	S-5	5.60	0.000	0.000	0.00	0.05	0.09	0.05	0.83	0.06	0.07
5-8	C-1	5.98	0.000	0.004	0.03	0.05	0.08	0.10	0.01	0.01	0.04
	C-2	6.29	0.000	0.007	0.04	0.07	0.00	0.02	0.01	0.03	0.03
	C-3	6.43	0.000	0.009	0.05	0.08	0.00	0.06	0.01	0.06	0.03
	C-4	6.55	0.000	0.007	0.04	0.08	0.04	0.02	0.00	0.06	0.02
	C-5	6.39	0.000	0.009	0.05	0.02	0.10	0.00	0.00	0.06	0.04
	C-6	6.52	0.000	0.015	0.05	0.01	0.03	0.04	0.02	0.16	0.07
	C-7	3.61	0.000	0.019	0.11	0.01	0.02	0.08	6.33	0.36	0.36
	C-8	6.31	0.000	0.000	0.01	0.03	0.03	0.01	0.00	0.07	0.04
5-13	H-1	2.44	0.000	0.010	0.08	0.03	0.19	6.59	2.27	0.24	2.84
	H-2	2.30	0.000	0.058	0.50	0.11	0.21	175.20	11.88	1.32	170.30
	H-31	2.21	0.001	0.073	0.59	0.11	0.27	160.60	15.07	1.53	221.60
	H-32	2.23	0.000	0.025	0.24	0.06	0.20	203.30	7.51	0.67	9.16
	H-4	2.35	0.000	0.024	0.25	0.07	0.32	203.30	10.33	0.72	8.96
	H-5	2.36	0.000	0.021	0.21	0.06	0.16	39.99	9.20	0.56	7.28
	H-6	5.92	0.000	0.000	0.04	0.00	0.07	15.73	0.01	0.02	0.00
	H-7	2.44	0.000	0.013	0.15	0.02	0.14	53.85	55.41	0.35	5.12
	H-8	3.14	0.000	0.000	0.04	0.06	0.08	2.75	14.03	0.08	1.10
6-4	S-1	7.34	0.000	0.000	0.02	0.02	0.02	70.77	0.02	0.11	0.01
	S-2	6.32	0.000	0.004	0.03	0.02	0.11	77.05	1.15	0.10	0.03
	S-3	2.61	0.000	0.106	0.54	0.08	0.29	199.50	32.91	1.39	3.91
	S-4	2.31	0.000	0.111	1.30	0.07	0.15	395.70	88.00	2.85	10.93
	S-5	2.69	0.000	0.006	0.12	0.02	0.04	79.75	10.28	0.31	0.52
	C-1	6.35	0.000	0.002	0.03	0.02	0.02	0.36	2.61	0.11	0.02
	C-2	6.72	0.000	0.005	0.04	0.01	0.11	0.02	1.92	0.06	0.08
	C-3	6.79	0.000	0.008	0.04	0.01	0.06	0.72	0.66	0.02	0.08
	C-4	6.73	0.000	0.013	0.07	0.01	0.05	0.00	4.47	0.10	0.08
	C-5	6.30	0.001	0.022	0.06	0.02	0.05	0.03	2.02	0.08	0.15
	C-6	7.19	0.000	0.029	0.06	0.02	0.03	0.03	3.22	0.08	0.30
	C-7	7.04	0.000	0.048	0.16	0.04	0.04	5.42	8.27	0.27	0.52
	C-8	-	0.000	0.051	0.07	0.08	0.06	0.18	4.60	0.02	0.31

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
6-4	H-1	2.59	0.003	0.608	3.25	0.37	0.90	4134.00	58.51	8.64	1767.00
	H-2	2.70	0.003	0.116	1.50	0.21	0.27	599.40	41.17	3.75	650.40
	H-31	2.65	0.003	0.163	1.37	0.20	0.29	359.00	37.91	3.43	621.50
	H-32	2.62	0.001	0.119	1.00	0.18	0.26	248.20	30.70	2.61	479.20
	H-4	2.63	0.001	0.098	0.86	0.15	0.31	225.30	28.12	2.13	376.60
	H-5	2.62	0.001	0.069	0.62	0.13	0.24	489.00	20.91	1.51	265.40
	H-6	6.92	0.000	0.019	0.19	0.05	0.14	289.80	6.41	0.50	7.60
	H-7	2.61	0.001	0.061	0.56	0.14	0.20	222.70	20.44	1.36	233.20
	H-8	2.79	0.000	0.015	0.17	0.05	0.24	135.90	6.85	0.41	5.68
6-18	S-1	7.09	0.000	0.002	0.00	0.04	0.05	0.30	0.56	0.00	0.03
	S-2	7.00	0.000	0.000	0.01	0.00	0.05	0.33	1.90	0.01	0.02
	S-3	2.80	0.000	0.163	0.82	0.10	0.40	325.30	53.13	2.04	5.28
	S-4	2.67	0.000	0.153	1.69	0.08	0.15	588.90	118.30	3.64	13.81
	S-5	3.28	0.001	0.012	0.13	0.02	0.20	31.60	14.79	0.34	0.72
	C-1	7.53	0.000	0.003	0.01	0.02	0.11	0.19	2.81	0.10	0.03
	C-2	7.33	0.000	0.001	0.03	0.03	0.01	1.51	3.05	0.11	0.03
	C-3	6.69	0.000	0.001	0.04	0.03	0.08	0.19	1.98	0.13	0.07
	C-4	7.68	0.000	0.000	0.06	0.05	0.02	0.19	5.00	0.12	0.04
	C-5	7.31	0.003	0.003	0.07	0.05	0.11	0.25	2.32	0.13	0.12
	C-6	7.62	0.000	0.003	0.06	0.02	0.04	0.10	4.14	0.16	0.23
	C-7	3.28	0.000	0.009	0.20	0.02	0.07	6.76	9.96	0.36	0.53
	C-8	7.29	0.000	0.006	0.08	0.01	0.08	0.56	5.87	0.05	0.03
	H-1	2.75	0.003	0.302	1.44	0.27	0.81	2420.00	23.55	3.28	54.25
	H-2	2.85	0.001	0.135	1.32	0.11	0.24	2359.00	38.19	2.95	48.30
	H-31	2.77	0.003	0.150	1.24	0.12	0.30	2003.00	36.62	2.87	50.55
	H-32	2.73	0.003	0.136	1.07	0.14	0.37	1736.00	32.58	2.51	44.93
	H-4	2.70	0.001	0.096	0.80	0.12	0.25	916.70	23.05	1.76	30.66
	H-5	2.68	0.001	0.088	0.74	0.12	0.27	905.10	22.40	1.61	28.08
	H-6	7.82	0.000	0.010	0.11	0.00	0.15	91.65	0.07	0.04	0.06
	H-7	2.67	0.001	0.072	0.65	0.11	0.35	578.50	19.72	1.35	25.80
	H-8	2.76	0.000	0.041	0.42	0.06	0.18	225.80	12.83	0.69	11.63
7-3	S-1	6.80	0.000	0.000	0.02	0.00	0.02	0.00	0.37	0.02	0.19
	S-2	6.60	0.000	0.000	0.01	0.00	0.02	0.54	1.37	0.06	0.30
	S-3	2.63	0.000	0.136	0.84	0.29	0.33	535.00	55.04	2.10	4.93
	S-4	2.43	0.000	0.160	1.98	0.52	0.19	790.30	133.70	4.41	14.53
	S-5	2.97	0.000	0.002	0.21	0.03	0.07	27.58	49.98	0.42	0.95
	C-1	6.54	0.000	0.000	0.06	0.00	0.03	0.03	2.28	0.06	0.15
	C-2	6.92	0.000	0.003	0.01	0.01	0.03	0.07	2.85	0.09	0.13
	C-3	7.15	0.000	0.002	0.00	0.01	0.04	0.38	1.08	0.07	0.20
	C-4	7.18	0.000	0.002	0.05	0.02	0.02	0.06	5.06	0.12	0.20
	C-5	7.37	0.000	0.001	0.09	0.02	0.04	0.13	0.93	0.08	0.10
	C-6	7.20	0.000	0.000	0.13	0.02	0.04	0.12	3.05	0.07	0.22
	C-7	3.20	0.000	0.006	0.07	0.00	0.05	4.43	8.87	0.30	0.47
	C-8	6.85	0.000	0.003	0.01	0.01	0.02	0.40	6.08	0.02	0.11
	H-1	2.29	0.003	0.875	0.46	1.88	1.14	9016.00	90.54	1.41	184.20
	H-2	2.67	0.003	0.155	1.12	1.01	1.90	2997.00	41.54	3.54	50.88
	H-31	2.58	0.003	0.155	1.08	0.95	0.21	2429.00	40.44	3.50	48.98
	H-32	2.53	0.003	0.147	1.00	0.94	0.25	2274.00	38.53	3.29	47.18
	H-4	2.59	0.001	0.110	0.78	0.78	0.25	1562.00	32.58	2.42	38.19
	H-5	2.47	0.000	0.100	0.68	0.71	0.25	726.00	15.55	2.12	17.57
	H-6	6.57	0.000	0.006	0.00	0.04	0.02	110.00	1.74	0.02	2.06
	H-7	2.36	0.001	0.087	0.61	0.44	0.24	752.90	25.47	1.74	25.44
	H-8	2.62	0.000	0.033	0.23	0.12	0.10	227.20	11.96	0.52	8.44
7-17	S-1	6.65	0.000	0.002	0.02	0.00	0.01	141.90	0.87	0.01	0.02
	S-2	6.53	0.000	0.000	0.03	0.02	0.03	108.20	2.45	0.02	0.04
	S-3	2.58	0.000	0.112	0.67	0.24	0.27	235.90	49.42	1.22	4.46
	S-4	2.26	0.000	0.193	2.01	0.58	0.18	752.90	178.10	3.51	16.10
	S-5	2.77	0.000	0.035	0.21	0.06	0.06	111.20	16.42	0.32	1.08
7-17	C-1	7.13	0.001	0.004	0.01	0.03	0.00	60.65	2.35	0.00	0.01
	C-2	6.59	0.000	0.004	0.05	0.02	0.00	48.29	2.85	0.02	0.06
	C-3	7.64	0.000	0.004	0.05	0.03	0.00	42.23	1.59	0.01	0.02
	C-4	2.38	0.000	0.007	0.06	0.03	0.00	32.13	6.20	0.06	0.23
	C-5	7.50	0.000	0.008	0.02	0.03	0.01	26.96	2.06	0.03	0.03
	C-6	7.08	0.000	0.006	0.05	0.03	0.00	18.31	4.35	0.08	0.06
	C-7	3.12	0.000	0.011	0.17	0.04	0.02	21.34	8.16	0.22	0.41
	C-8	7.35	0.000	0.009	0.07	0.04	0.00	17.19	5.58	0.00	0.01
	H-2	2.59	0.003	0.152	1.61	1.20	0.21	3337.00	64.02	3.68	58.78
	H-31	2.55	0.003	0.145	1.30	1.05	0.26	2680.00	51.67	3.03	68.52
	H-32	2.48	0.003	0.122	1.06	0.94	0.25	2212.00	44.15	2.42	54.25
	H-4	2.38	0.003	0.098	0.87	0.86	0.32	1810.00	39.99	2.02	45.26
	H-5	2.33	0.003	0.088	0.85	0.84	0.34	1709.00	39.99	1.93	44.48
	H-6	6.48	0.000	0.000	0.01	0.00	0.00	205.10	0.65	0.00	0.01
	H-7	6.87	0.002	0.084	0.82	0.74	0.34	1069.00	28.77	1.63	41.56
	H-8	2.18	0.000	0.058	0.80	0.49	0.26	664.20	46.05	1.14	21.93
7-31	S-1	6.50	0.000	0.015	0.14	0.02	0.01	0.69	0.57	0.02	0.02
	S-2	6.60	0.000	0.016	0.16	0.02	0.01	1.40	1.48	0.02	0.02
	S-3	2.81	0.000	0.130	0.86	0.26	0.19	137.40	49.33	1.48	4.32
	S-4	2.51	0.000	0.176	0.00	0.26	0.18	451.60	190.50	3.95	15.80
	S-5	3.19	0.000	0.011	0.19	0.01	0.04	6.19	14.57	0.26	0.63
	C-1	6.89	0.000	0.027	0.19	0.00	0.03	0.26	2.37	0.05	0.06
	C-2	7.20	0.000	0.028	0.17	0.00	0.02	0.42	2.47	0.06	0.04
	C-3	7.31	0.000	0.030	0.19	0.00	0.01	0.80	1.49	0.10	0.04
	C-4	6.90	0.000	0.024	0.16	0.00	0.01	0.33	2.66	0.04	0.05
	C-5	7.11	0.000	0.005	0.18	0.00	0.01	0.13	2.08	0.07	0.05
	C-6	7.30	0.000	0.010	0.16	0.00	0.02	0.33	3.26	0.10	0.07
	C-7	3.70	0.000	0.013	0.27	0.03	0.01	4.55	8.03	0.26	0.39
	C-8	7.16	0.000	0.015	0.14	0.03	0.01	0.74	4.70	0.06	0.02
	H-1	2.40	0.003	0.546	2.13	1.70	1.42	5615.00	32.15	4.66	85.64
	H-2	2.85	0.003	0.195	1.80	1.06	0.35	4807.00	47.44	3.98	64.81
	H-31	2.70	0.003	0.188	1.44	0.76	0.29	3609.00	40.56	3.48	56.91
	H-32	2.65	0.003	0.138	1.20	0.50	1.87	3052.00	36.02	2.90	47.80
	H-4	2.60	0.001	0.097	0.89	0.34	0.30	2324.00	28.27	2.04	34.21
	H-5	2.59	0.002	0.088	0.85	0.35	0.31	1196.00	26.60	1.87	31.78
	H-6	6.85	0.000	0.000	0.05	0.02	0.03	287.60	0.35	0.04	0.01
	H-7	2.62	0.001	0.080	0.73	0.28	0.33	874.20	22.62	1.52	26.02
	H-8	2.88	0.000	0.026	0.24	0.04	0.33	253.90	8.52	0.45	8.48
8-16	S-1	6.82	0.000	0.002	0.06	0.02	0.02	0.53	0.56	0.03	0.01
	S-2	6.42	0.000	0.000	0.06	0.01	0.01	0.03	1.50	0.06	0.03
	S-3	2.71	0.000	0.141	0.53	0.19	0.22	192.40	27.02	1.00	3.56
	S-4	2.40	0.000	0.203	2.08	0.39	0.22	1847.00	175.00	3.89	16.32
	S-5	3.17	0.000	0.011	0.04	0.01	0.04	2.36	8.16	0.21	0.49
	C-1	7.03	0.000	0.003	0.00	0.03	0.01	0.00	1.76	0.07	0.01
	C-2	7.33	0.000	0.002	0.00	0.01	0.01	0.00	2.35	0.04	0.02
	C-3	7.53	0.000	0.002	0.00	0.00	0.01	0.08	0.71	0.02	0.02
	C-4	7.50	0.000	0.003	0.02	0.02	0.02	0.00	3.34	0.12	0.03
	C-5	7.34	0.000	0.003	0.08	0.02	0.02	0.00	0.48	0.07	0.02
	C-6	7.63	0.000	0.003	0.05	0.03	0.02	0.00	1.31	0.04	0.02
	C-7	3.13	0.000	0.009	0.11	0.00	0.06	4.14	8.50	0.25	0.35
	C-8	6.66	0.000	0.005	0.01	0.01	0.03	0.03	5.08	0.02	0.01
	H-2	2.72	0.001	0.144	1.36	0.80	0.11	3825.00	41.62	2.88	47.89
	H-31	2.58	0.003	0.167	1.28	0.75	0.14	4421.00	42.68	2.90	52.95
	H-32	2.48	0.003	0.148	1.18	0.72	0.18	4324.00	37.35	2.59	44.35
	H-4	2.47	0.002	0.125	1.02	0.63	0.15	3828.00	34.15	2.18	37.97
	H-5	2.44	0.003	0.126	0.98	0.64	0.16	3693.00	33.40	2.17	37.25
	H-6	7.63	0.000	0.000	0.08	0.00	0.00	0.00	0.09	0.04	0.01
	H-7	2.39	0.001	0.110	0.85	0.62	0.21	3153.00	31.27	1.91	30.02
	H-8	2.45	0.001	0.046	0.40	0.27	0.11	494.10	12.25	0.82	12.19

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
8-30	S-1	6.56	0.000	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.01
	S-2	6.85	0.002	0.163	0.00	0.00	0.00	0.27	0.16	0.00	0.01
	S-3	2.61	0.000	0.096	0.55	0.19	0.22	478.40	37.06	1.19	4.86
	S-4	2.39	0.000	0.214	2.09	0.43	0.20	4354.00	189.20	4.17	16.49
	S-5	2.88	0.000	0.033	0.13	0.00	0.03	242.50	13.49	0.24	0.66
	C-1	6.96	0.000	0.023	0.01	0.00	0.00	0.00	0.01	0.03	0.01
	C-2	7.05	0.000	0.024	0.00	0.00	0.00	0.00	0.01	0.03	0.01
	C-3	7.54	0.000	0.009	0.02	0.00	0.00	0.22	0.27	0.08	0.01
	C-4	6.28	0.000	0.027	0.05	0.00	0.01	0.02	4.34	0.07	0.11
	C-5	7.40	0.000	0.027	0.03	0.01	0.00	0.06	0.29	0.05	0.03
	C-6	7.07	0.000	0.032	0.04	0.01	0.00	0.00	2.02	0.09	0.03
	C-7	3.14	0.000	0.036	0.14	0.01	0.03	12.05	1.34	0.26	0.39
	C-8	7.57	0.000	0.028	0.04	0.00	0.00	0.00	5.08	0.05	0.04
	H-2	2.75	0.003	0.133	1.13	0.82	0.14	-	41.62	2.52	40.36
	H-31	2.57	0.003	0.134	1.08	0.75	0.18	-	42.68	2.40	42.47
	H-32	2.54	0.003	0.095	0.74	0.57	0.14	-	37.35	1.65	26.23
	H-4	2.49	0.002	0.093	0.73	0.56	0.16	-	20.87	1.67	26.10
	H-5	2.50	0.002	0.107	0.70	0.65	0.19	-	22.76	1.90	28.65
	H-6	7.36	0.000	0.006	0.02	0.06	0.00	14.08	0.52	0.02	0.12
	H-7	2.46	0.003	0.091	0.72	0.59	0.19	392.00	21.32	1.69	25.78
	H-8	2.72	0.002	0.013	0.10	0.07	0.04	105.20	2.69	0.16	2.45
9-13	S-1	6.54	0.000	0.015	0.02	0.00	0.01	0.02	0.41	0.02	0.00
	S-2	6.36	0.000	0.011	0.00	0.03	0.01	0.00	1.02	0.04	0.02
	S-3	2.54	0.000	0.391	2.06	0.84	0.66	2539.00	147.90	5.34	11.63
	S-4	2.30	0.000	0.227	2.09	0.60	0.15	812.10	218.30	5.49	14.83
	S-5	2.88	0.000	0.028	0.20	0.10	0.03	8.20	14.32	0.31	0.53
	C-1	6.72	0.000	0.026	0.08	0.10	0.02	0.03	2.36	0.01	0.01
	C-2	6.91	0.000	0.021	0.05	0.12	0.02	0.02	2.28	0.07	0.02
	C-3	6.53	0.000	0.016	0.06	0.00	0.01	2.21	3.08	0.14	0.01
	C-5	-	0.000	0.014	0.06	0.03	0.02	0.12	7.13	0.24	0.05
	C-6	6.65	0.000	0.012	0.11	0.04	0.03	0.00	4.99	0.14	0.02
	C-7	3.06	0.000	0.004	0.18	0.07	0.03	5.70	9.71	0.34	0.37
	C-8	6.65	0.000	0.000	0.06	0.07	0.02	0.00	61.14	0.04	0.01
	H-2	2.59	0.000	0.123	1.58	1.06	0.13	2972.00	67.23	3.44	57.81
	H-31	2.51	0.002	0.170	1.40	0.89	0.14	2447.00	60.82	3.48	58.16
	H-32	2.51	0.003	0.162	1.35	0.91	0.13	2373.00	59.76	3.84	58.01
	H-6	7.00	0.000	0.006	0.07	0.00	0.00	0.04	0.20	0.02	0.00
	H-7	2.36	0.003	0.089	0.79	0.61	0.22	962.30	28.26	2.04	23.30
	H-8	2.72	0.000	0.028	0.29	0.07	0.05	159.30	18.11	0.33	3.01
9-27	S-1	6.17	0.000	0.000	0.04	0.00	0.00	0.06	0.58	0.08	0.02
	S-2	5.51	0.000	0.010	0.03	0.00	0.00	0.05	3.63	0.07	0.08
	S-3	2.62	0.000	0.418	2.21	0.99	0.69	6297.00	168.90	5.37	13.46
	S-4	2.33	0.000	0.196	2.21	0.53	0.20	4930.00	195.90	3.94	16.04
	S-5	2.82	0.000	0.021	0.09	0.12	0.08	436.50	16.07	0.42	1.00
	C-1	6.92	0.000	0.000	0.03	0.00	0.01	0.04	1.58	0.12	0.01
	C-2	6.89	0.000	0.006	0.04	0.00	0.02	0.05	1.54	0.12	0.02
	C-3	6.72	0.000	0.007	0.06	0.01	0.01	0.11	1.08	0.15	0.01
	C-4	7.24	0.000	0.008	0.07	0.00	0.01	0.02	3.93	0.02	0.02
	C-5	7.62	0.000	0.002	0.11	0.05	0.01	0.00	1.50	0.13	0.05
	C-6	7.18	0.000	0.004	0.19	0.02	0.01	0.03	10.46	0.20	0.07
	C-7	3.46	0.000	0.010	0.30	0.10	0.04	3.47	4.91	0.23	0.48
	C-8	6.86	0.000	0.008	0.18	0.10	0.01	0.00	147.90	0.00	0.01
10-11	S-1	7.35	0.000	0.000	0.04	0.03	0.00	0.07	0.12	0.07	0.00
	S-2	6.68	0.000	0.007	0.05	0.05	0.00	0.03	4.30	0.10	0.00
	S-3	3.04	0.002	0.330	1.44	1.43	0.70	846.30	154.70	3.81	12.19
	S-4	2.58	0.002	0.184	1.86	0.58	0.18	715.50	220.10	4.02	15.11
	S-5	3.27	0.000	0.014	0.14	0.04	0.04	8.10	14.36	0.32	0.46
10-11	C-1	7.33	0.000	0.004	0.04	0.06	0.02	0.19	2.21	0.10	0.00
	C-2	7.14	0.000	0.001	0.03	0.05	0.02	0.04	2.68	0.13	0.00
	C-3	7.44	0.000	0.002	0.02	0.06	0.01	0.07	0.46	0.12	0.00
	C-4	7.38	0.000	0.005	0.03	0.05	0.01	0.00	6.85	0.15	0.02
	C-5	7.00	0.000	0.012	0.02	0.07	0.00	0.01	1.61	0.25	0.00
	C-6	7.29	0.000	0.005	0.06	0.07	0.02	0.01	7.54	0.30	0.04
	C-7	3.24	0.000	0.005	0.12	0.07	0.04	7.65	11.60	0.44	0.32
	C-8	6.96	0.000	0.000	0.03	0.02	0.02	0.00	5.92	0.11	0.00
10-25	S-1	7.28	0.000	0.001	0.02	0.00	0.01	0.09	0.35	0.04	0.02
	S-2	4.78	0.000	0.006	0.06	0.00	0.02	2.57	0.56	0.14	0.18
	S-3	2.79	0.001	0.342	1.92	0.98	0.51	1113.00	130.20	4.64	13.74
	S-4	2.37	0.000	0.183	2.22	0.68	0.16	1196.00	170.00	4.53	16.49
	S-5	3.19	0.000	0.015	0.13	0.00	0.03	9.73	11.94	0.26	0.61
	C-1	7.43	0.000	0.000	0.00	0.03	0.00	0.10	4.06	0.13	0.02
	C-2	7.49	0.000	0.000	0.00	0.03	0.01	0.15	1.98	0.12	0.09
	C-3	7.23	0.000	0.002	0.00	0.04	0.01	0.15	0.53	0.13	0.04
	C-4	7.60	0.000	0.005	0.01	0.04	0.01	0.04	4.44	0.16	0.05
	C-5	7.77	0.000	0.004	0.00	0.05	0.01	0.03	0.58	0.05	0.01
	C-6	7.82	0.000	0.004	0.00	0.05	0.00	0.01	2.89	0.12	0.06
	C-7	3.18	0.000	0.006	0.10	0.08	0.01	15.43	11.91	0.34	0.57
	C-8	7.34	0.000	0.003	0.04	0.04	0.00	0.05	4.57	0.00	0.02
	H-2	2.81	0.003	0.096	1.56	1.43	0.12	2960.00	53.35	4.10	55.43
	H-31	2.59	0.003	0.133	1.34	1.27	0.20	2530.00	48.02	3.74	52.13
	H-32	2.50	0.003	0.106	1.19	1.07	0.20	2260.00	44.07	3.41	47.11
	H-4	2.36	0.003	0.105	1.07	0.96	0.28	1913.00	36.94	3.12	43.39
	H-5	2.35	0.003	0.102	1.04	0.94	0.27	1763.00	35.98	3.02	42.21
	H-6	7.46	0.000	0.000	0.03	0.02	0.00	0.29	1.18	0.07	0.01
	H-7	2.30	0.003	0.090	0.89	0.89	0.32	1230.00	29.23	2.50	34.22
	H-8	2.51	0.003	0.048	0.51	0.41	0.16	563.50	24.28	1.35	21.10
11-6	S-1	6.79	0.000	0.010	0.07	0.00	0.00	0.07	0.22	0.08	0.00
	S-3	2.90	0.000	0.437	2.33	1.43	0.62	2127.00	187.10	5.35	15.97
	S-4	2.37	0.000	0.185	2.06	0.72	0.22	1081.00	172.90	4.12	15.11
	S-5	3.10	0.000	0.033	0.19	0.06	0.01	22.31	18.70	0.44	0.79
	C-1	7.18	0.000	0.010	0.05	0.03	0.00	0.00	3.11	0.12	0.00
	C-2	7.12	0.000	0.012	0.05	0.03	0.00	0.05	2.77	0.15	0.02
	C-3	7.04	0.000	0.008	0.03	0.03	0.00	0.04	1.38	0.13	0.01
	C-4	7.08	0.000	0.010	0.04	0.04	0.03	0.00	5.30	0.14	0.04
	C-5	7.02	0.000	0.009	0.02	0.04	0.02	0.02	1.09	0.18	0.02
	C-6	7.18	0.000	0.010	0.04	0.05	0.01	0.01	2.67	0.14	0.01
	C-7	3.06	0.000	0.014	0.15	0.04	0.03	20.52	12.00	0.47	0.51
	C-8	7.02	0.000	0.003	0.01	0.03	0.01	0.05	3.75	0.08	0.00
11-27	S-1	7.32	0.000	0.000	0.05	0.01	0.03	0.47	0.22	0.07	0.06
	S-2	7.12	0.000	0.000	0.05	0.01	0.03	0.48	0.18	0.00	0.02
	S-3	4.46	0.000	0.004	0.06	0.03	0.04	12.32	3.36	0.04	0.24
	S-4	2.67	0.000	0.011	1.21	0.37	0.22	515.40	82.11	2.37	11.05
	S-5	4.90	0.000	0.001	0.02	0.03	0.05	3.86	4.10	0.03	0.15
	C-1	6.86	0.000	0.000	0.01	0.01	0.03	0.20	0.84	0.00	0.04
	C-2	7.05	0.000	0.000	0.00	0.01	0.02	0.27	0.95	0.00	0.38
	C-3	7.35	0.000	0.000	0.04	0.01	0.04	0.04	2.18	0.04	0.32
	C-4	7.51	0.000	0.002	0.00	0.02	0.02	0.25	1.15	0.02	0.11
	C-5	7.60	0.000	0.002	0.02	0.02	0.03	0.80	2.44	0.06	0.05
	C-6	7.81	0.000	0.002	0.00	0.02	0.03	0.02	3.73	0.09	0.09
	C-7	3.48	0.000	0.005	0.07	0.04	0.02	4.68	5.68	0.20	0.39
	C-8	7.29	0.000	0.003	0.01	0.01	0.02	0.45	1.14	0.01	0.06

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
11-27	H-1	4.54	0.000	0.005	0.03	0.03	0.03	5.52	4.71	0.11	1.00
	H-2	3.01	0.003	0.079	0.65	0.69	0.12	1400.00	18.28	1.78	29.20
	H-31	2.95	0.003	0.090	0.69	0.71	0.15	1575.00	22.58	2.08	32.86
	H-32	3.02	0.003	0.053	0.50	0.52	0.13	1440.00	19.73	1.53	23.87
	H-4	3.13	0.003	0.021	0.16	0.20	0.05	500.80	8.88	0.52	9.12
	H-5	3.05	0.002	0.026	0.22	0.29	0.08	672.30	11.22	0.74	13.88
	H-6	7.59	0.000	0.000	0.00	0.02	0.02	0.57	0.37	0.01	0.07
	H-7	3.05	0.003	0.021	0.22	0.24	0.07	486.20	8.99	0.58	10.95
	H-8	3.64	0.000	0.004	0.10	0.06	0.03	69.07	2.16	0.13	1.92
12-13	S-1	7.18	0.000	0.000	0.05	0.06	0.03	0.02	0.48	0.07	0.03
	S-2	6.85	0.000	0.000	0.02	0.01	0.02	0.45	0.38	0.06	0.00
	S-3	4.84	0.000	0.000	0.00	0.04	0.03	5.33	1.77	0.12	0.08
	S-4	2.51	0.000	0.079	1.24	0.48	0.11	558.60	80.19	2.65	8.49
	S-5	4.99	0.000	0.000	0.04	0.05	0.02	1.65	3.27	0.07	0.11
	C-1	6.74	0.000	0.000	0.00	0.07	0.02	0.07	2.18	0.12	0.00
	C-2	6.83	0.000	0.000	0.00	0.04	0.01	0.19	1.97	0.04	0.01
	C-3	7.03	0.000	0.000	0.17	0.01	0.01	0.09	0.88	0.07	0.00
	C-4	7.04	0.000	0.031	0.03	0.00	0.02	0.20	2.53	0.11	0.00
	C-5	7.28	0.000	0.001	0.07	0.04	0.01	0.07	0.81	0.10	0.03
	C-6	7.64	0.000	0.006	0.08	0.05	0.02	0.15	2.02	0.00	0.04
	C-7	3.22	0.000	0.007	0.10	0.02	0.01	0.12	7.35	0.22	0.35
	C-8	7.03	0.000	0.001	0.06	0.01	0.01	0.46	3.84	0.02	0.06
	H-1	5.33	0.000	0.007	0.04	0.01	0.00	0.97	1.74	0.05	0.36
	H-2	2.48	0.003	0.079	0.41	0.68	0.36	1049.00	14.01	1.44	16.42
	H-31	2.75	0.003	0.079	0.54	0.71	0.16	1137.00	17.66	1.70	20.14
	H-32	2.55	0.000	0.078	0.42	0.64	0.14	1046.00	16.46	1.52	17.52
	H-4	2.70	0.000	0.067	0.36	0.48	0.11	783.80	11.71	1.12	13.02
	H-5	2.75	0.000	0.042	0.25	0.30	0.06	429.00	6.63	0.74	8.49
	H-6	6.96	0.000	0.019	0.01	0.02	0.00	0.11	0.24	0.18	0.00
	H-8	2.95	0.000	0.017	0.10	0.14	0.03	215.60	3.81	0.37	3.54
1-10	S-1	7.23	0.000	0.000	0.00	0.11	0.03	0.33	0.43	0.01	0.03
	S-2	6.86	0.000	0.001	0.00	0.10	0.02	0.33	0.92	0.01	0.01
	S-3	4.52	0.000	0.013	0.08	0.20	0.03	53.78	7.30	0.25	0.49
	S-4	2.54	0.000	0.109	0.70	0.75	0.11	357.60	48.38	1.96	8.68
	S-5	4.59	0.000	0.009	0.05	0.11	0.02	19.18	9.50	0.27	0.28
	C-1	7.10	0.000	0.001	0.05	0.08	0.03	0.27	2.38	0.13	0.04
	C-2	7.26	0.000	0.007	0.02	0.00	0.04	0.11	2.14	0.13	0.01
	C-3	7.28	0.000	0.004	0.00	0.00	0.02	1.15	1.21	0.15	0.05
	C-4	7.38	0.000	0.009	0.03	0.00	0.02	0.09	3.40	0.05	0.04
	C-5	7.35	0.000	0.006	0.05	0.06	0.02	0.05	1.10	0.05	0.07
	C-6	3.35	0.000	0.012	0.04	0.06	0.04	0.05	2.68	0.08	0.06
	C-7	3.35	0.000	0.026	0.11	0.13	0.05	26.74	11.70	0.24	0.33
	C-8	7.24	0.000	0.000	0.00	0.07	0.05	0.34	0.94	0.01	0.02
	H-1	4.52	0.000	0.000	0.01	0.05	0.05	3.69	2.88	0.09	0.49
	H-2	2.95	0.003	0.066	0.51	1.33	0.15	2876.00	16.77	1.35	2.50
	H-31	2.88	0.003	0.071	0.65	1.31	0.14	2145.00	12.16	1.27	1.12
	H-32	4.50	0.003	0.023	0.08	0.19	0.04	147.70	2.97	0.21	1.83
	H-4	2.95	0.003	0.048	0.27	0.63	0.10	597.90	12.42	0.67	9.77
	H-5	3.02	0.000	0.009	0.24	0.57	0.09	495.30	10.91	0.63	7.74
	H-6	7.17	0.000	0.001	0.02	0.07	0.02	0.53	0.43	0.09	0.02
	H-7	2.97	0.000	0.024	0.21	0.51	0.09	394.90	10.76	0.58	7.57
	H-8	4.54	0.000	0.001	0.08	0.18	0.08	111.50	2.77	0.16	1.48
1-23	S-1	7.32	0.000	0.025	0.05	0.06	0.03	0.09	0.34	0.02	0.03
	S-2	7.15	0.000	0.007	0.01	0.07	0.02	0.13	0.85	0.03	0.02
	S-3	4.03	0.000	0.007	0.07	0.05	0.03	39.02	4.65	0.33	0.45
	S-4	2.18	0.000	0.093	0.88	0.51	0.14	578.10	70.09	1.76	9.18
	S-5	4.59	0.000	0.018	0.14	0.03	0.02	7.81	3.25	0.12	0.21
1-23	C-1	6.89	0.000	0.014	0.13	0.03	0.03	0.35	1.85	0.16	0.08
	C-2	6.83	0.000	0.008	0.28	0.02	0.03	0.34	1.64	0.19	0.08
	C-3	6.09	0.000	0.016	0.17	0.01	0.03	1.65	1.50	0.19	0.08
	C-4	2.47	0.000	0.015	0.03	0.03	0.04	1.10	2.08	0.05	0.03
	C-5	6.56	0.000	0.015	0.24	0.03	0.04	0.15	1.50	0.15	0.03
	C-6	6.95	0.000	0.018	0.05	0.03	0.06	0.16	2.76	0.22	0.05
	C-7	2.89	0.000	0.002	0.12	0.04	0.04	16.52	5.57	0.31	0.40
	C-8	6.58	0.000	0.010	0.45	0.06	0.03	1.83	3.22	0.09	0.03
	H-1	3.93	0.000	0.004	0.15	0.04	0.02	20.77	1.84	0.05	0.87
	H-2	2.64	0.003	0.067	0.41	0.81	0.12	2100.00	9.31	1.03	18.28
	H-31	2.60	0.003	0.063	0.41	0.75	0.12	2212.00	15.66	0.98	21.06
	H-32	3.48	0.000	0.017	0.15	0.18	0.03	204.10	3.32	0.15	3.49
	H-4	2.33	0.001	0.028	0.31	0.34	0.06	400.10	7.40	0.38	8.53
	H-5	2.62	0.000	0.023	0.43	0.29	0.03	286.90	6.46	0.31	6.55
	H-6	3.03	0.000	0.011	0.04	0.04	0.04	0.44	0.39	0.02	0.00
	H-7	2.57	0.000	0.006	0.22	0.24	0.08	237.50	5.47	0.40	5.51
	H-8	4.23	0.000	0.003	0.03	0.06	0.08	38.48	1.78	0.18	1.33
2-6	S-2	7.26	0.000	0.025	0.01	0.04	0.02	0.70	1.11	0.18	0.03
	S-3	4.57	0.000	0.039	0.09	0.23	0.06	43.49	9.00	0.21	0.90
	S-4	2.75	0.000	0.099	1.13	0.68	0.18	206.00	75.13	2.52	9.02
	S-5	5.07	0.000	0.025	0.04	0.08	0.04	14.02	6.07	0.20	0.36
	C-3	6.50	0.000	0.002	0.04	0.16	0.03	2.60	1.45	0.03	0.04
	C-4	6.68	0.000	0.017	0.04	0.08	0.03	0.98	3.54	0.11	0.07
	C-5	6.67	0.000	0.011	0.09	0.09	0.06	0.06	1.69	0.08	0.09
	C-6	6.70	0.000	0.018	0.03	0.89	0.04	0.10	2.67	0.16	0.10
	C-7	3.50	0.000	0.029	0.14	0.08	0.04	16.66	7.38	0.37	0.42
	C-8	6.42	0.000	0.028	0.05	0.05	0.01	5.68	3.87	0.04	0.05
	H-4	3.06	0.000	0.014	0.19	0.46	0.11	204.20	9.90	0.66	9.57
	H-5	3.15	0.000	0.016	0.18	0.50	0.43	180.20	8.66	0.56	8.32
2-21	S-1	7.26	0.000	0.009	0.11	0.00	0.09	0.33	0.24	0.10	0.03
	S-2	7.03	0.000	0.013	0.07	0.00	0.04	0.24	0.53	0.07	0.02
	S-3	4.72	0.000	0.010	0.06	0.02	0.04	10.86	2.39	0.02	0.16
	S-4	2.71	0.000	0.083	0.95	0.57	0.17	274.80	65.96	2.17	7.34
	S-5	6.17	0.000	0.012	0.16	0.02	0.04	3.43	2.28	0.09	0.07
	C-1	7.04	0.000	0.018	0.04	0.02	0.05	0.64	1.15	0.16	0.02
	C-2	6.91	0.000	0.003	0.09	0.07	0.03	0.48	1.06	0.04	0.00
	C-3	6.72	0.000	0.003	0.16	0.03	0.06	0.29	2.19	0.17	0.12
	C-4	7.17	0.000	0.004	0.06	0.03	0.01	0.49	1.05	0.07	0.00
	C-5	6.83	0.000	0.003	0.04	0.04	0.03	0.38	2.06	0.12	0.03
	C-6	6.92	0.000	0.011	0.06	0.00	0.03	0.47	3.50	0.10	0.11
	C-7	6.46	0.000	0.010	0.06	0.05	0.04	2.17	2.55	0.15	0.09
	C-8	6.98	0.000	0.010	0.01	0.01	0.03	0.86	1.13	0.08	0.00
3-6	S-1	7.43	0.000	0.093	0.21	0.00	0.06	0.18	0.29	0.08	0.01
	S-2	6.94	0.000	0.005	0.00	0.00	0.01	0.14	0.59	0.06	0.00
	S-3	4.65	0.000	0.001	0.00	0.06	0.02	9.93	2.33	0.13	0.21
	S-4	2.62	0.000	0.065	0.95	0.17	0.13	285.40	84.56	2.33	9.50
	S-5	6.36	0.000	0.000	0.00	0.02	0.04	1.02	1.75	0.11	0.02
	C-1	7.13	0.000	0.012	0.02	0.08	0.00	0.17	1.45	0.16	0.00
	C-2	7.17	0.000	0.000	0.00	0.07	0.01	0.07	1.32	0.40	0.06
	C-3	6.91	0.000	0.003	0.05	0.12	0.01	0.05	1.66	0.08	0.10
	C-4	7.14	0.000	0.010	0.02	0.03	0.00	0.06	1.72	0.04	0.04
	C-5	7.37	0.000	0.019	0.04	0.08	0.00	0.16	1.78	0.16	0.08
	C-6	7.59	0.000	0.014	0.15	0.04	0.04	0.12	2.59	0.16	0.11
	C-7	3.18	0.000	0.018	0.24	0.04	0.07	7.59	8.00	0.21	0.49
	C-8	5.92	0.000	0.018	0.17	0.01	0.04	0.06	2.75	0.04	0.04

Date	Loc.	pH	As	Cd	Co	Cr	Cu	Fe	Mn	Ni	Zn
3-20	C-1	3.80	0.000	0.013	0.02	0.02	0.04	1.92	0.56	0.06	0.07
	C-2	3.15	0.000	0.026	0.01	0.01	0.05	0.49	0.82	0.02	0.04
	C-3	4.45	0.000	0.043	0.01	0.00	0.03	0.39	1.71	0.02	0.06
	C-4	5.80	0.000	0.003	0.01	0.01	0.10	0.18	0.79	0.00	0.02
	C-5	7.16	0.000	0.000	0.03	0.01	0.09	0.47	2.11	0.10	0.10
	C-6	7.56	0.000	0.011	0.09	0.01	0.05	0.08	2.75	0.07	0.15
	C-7	3.72	0.000	0.000	0.09	0.02	0.04	2.94	3.23	0.18	0.28
	C-8	7.34	0.000	0.008	0.15	0.00	0.07	0.37	8.77	0.07	0.00